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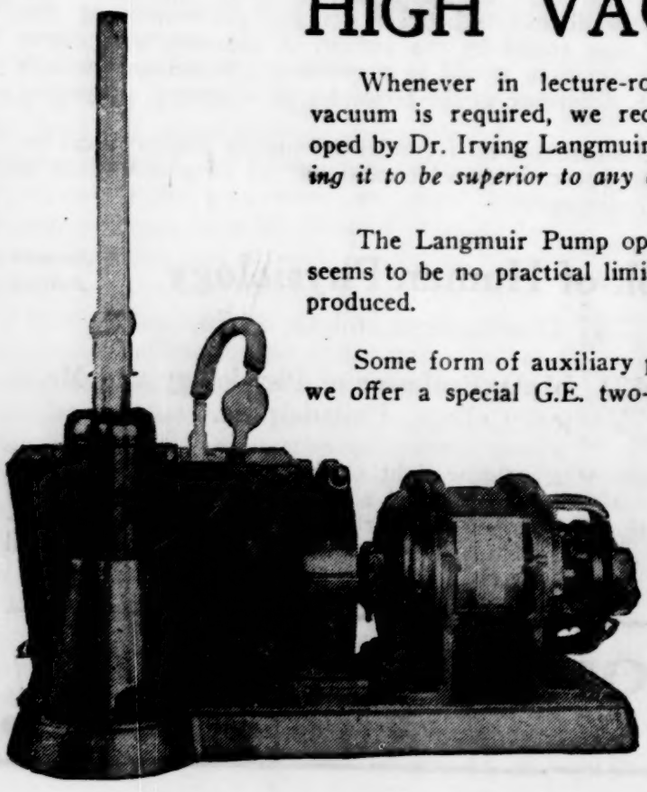

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INTERNATIONAL AND INTERSTATE ASPECTS OF THE COLORADO RIVER PROBLEM[1]

THE Colorado River has a drainage basin 244,000 square miles in extent. Parts of seven states and a small section of Mexico are embraced within this watershed. But the amount of water contributed to the discharge of the river by the several states and by Mexico bears no definite relation to the extent of watershed in each. This will be seen from the following figures compiled from records of the United States Geological Survey:

Political Subdivision	Watershed Area
	sq. miles
Colorado	39,000
Wyoming	19,000
Utah	40,000
Nevada	12,000
New Mexico	23,000
Arizona	103,000
California	6,900
Total United States	242,000
Mexico	2,000
Total	244,000

The mean annual discharge of Colorado River and its tributaries is indicated by the following figures:

Name of Stream	Drainage Area square miles	Discharge acre-feet
Green River	44,000	5,510,000
Grand River (Upper Colorado)	26,000	6,940,000
San Juan River	26,000	2,700,000
Other tributaries, not including the Gila	91,000	1,560,000
Gila River	47,000	1,070,000
Colorado River at Laguna Dam		16,400,000

[1]Symposium on "The Problems of the Colorado River," American Association for the Advancement of Science, Salt Lake City.

Beneficial use of the waters of Colorado River commenced many years ago. No attempt will be made in this sketch to do more than to give the briefest outline of historical facts.

The extent to which the water of Colorado River is being used for irrigation will appear from the following figures compiled by Mr. E. C. LaRue for 1913.

Colorado; area irrigated in 1913 was 440,000 acres.

Wyoming; area irrigated in 1913 was 280,000 acres.

Utah; area irrigated in 1913 was 204,000 acres.

Nevada; area irrigated in 1913 was 5,000 acres.

New Mexico; area irrigated in 1913 was 40,000 acres.

Arizona; area irrigated in 1913 was 315,000 acres.

California; area irrigated in 1913 was 297,000 acres.

Mexico; area irrigated in 1913 was 50,000 acres.

In California the irrigated area now approaches 500,000 acres and in Mexico it is about 190,000 acres. There has, of course, also, been extension of irrigation in the upper states but later figures are not at hand.

No Colorado River water was used for irrigation in Mexico prior to the construction of the Imperial Canal from which water began to be used in 1901. By 1905 there were about 5,000 acres of land in Lower California being irrigated. In 1910 the area was probably about 20,000 acres and in 1920 had reached about 150,000 acres.

The potential use of water from this river and its tributaries can not be stated with any great degree of precision. Some allowances must be made for the fact that just at present each of the several interested states is endeavoring to secure recognition of extreme ultimate possibilities in this connection rather than of early future probabilities. For the purpose of a guide in this discussion the following figures are noted—the endeavor being to include in the areas noted as irrigable only such as would seem to justify construction of works within the next thirty years.

In the Green River Basin the extent of irrigation in 1913 was about 500,000 acres and expansion within thirty years to about 900,000 acres is to be expected; in the Grand River Basin from about 300,000 to about 420,000 acres; on the lower Colorado from about 400,000 acres to 1,500,000 acres; in the Gila River Basin from 280,000 to some uncertain extent possibly 400,000 acres; in the San Juan River Basin from 117,000 to 500,000 acres; in the basins of the lesser tributaries of Colorado River from about 61,000 acres in 1913 to about 160,000 acres, and in Mexico from 50,000 in 1913 and 190,000 in 1921 to 600,000 acres.

After the war between the United States and Mexico the boundary line between the two countries had to be fixed. This was done in a conference resulting in a boundary line treaty consummated in 1848. But it was soon found that portions of the line westerly from the Rio Grande should have been placed further south and negotiations were commenced for a modification of the line. The result of these negotiations (in 1853) was the acquisition of a strip of land, now the south portion of New Mexico and Arizona known as the Gadsden Purchase. There is a story current, though probably impossible of verification and to be considered for the present as without foundation in fact, to the effect that the Commissioners of the United States who made the purchase were given the choice of three locations for a new line. According to this story the line furthest to the south touches the head of the Gulf; but the payments to be made by the United States to Mexico were graded according to the distance that the boundary would be shifted southward and the line requiring the least payment was selected by the United States Commissioners. Whether this story be true or not we can now see how unfortunate it was to have fixed the line in its established position. It should have been as far south as the head of the Gulf of California so that the entire delta of the Colorado River would have been in the United States. The Commissioners accepted a location of the line which may at any time become a source of friction and which has already become a matter of great inconvenience and some embarrassment to the United States. The boundary divides the delta of the river not along a channel, which would be bad enough, but in such a way that most of the delta slope

toward the south and some of the slope toward the north remains in Mexico.

The absurdity of the resulting situation is daily becoming more apparent and the interruption of diplomatic relations with Mexico (from 1913 to date) has thus far prevented the taking of steps to ameliorate a situation, involving river work in Mexico for the joint benefit of the two countries, which is fast becoming intolerable. It may be remarked, too, that the seriousness of the situation and the importance of having adequate control of the delta section of the river vested in some agency which can accomplish results is not generally recognized.

Recall for a clearer understanding of this international political matter the essential physical facts:

The Colorado River was found on a course to the Gulf of California 400 years ago by Spanish explorers. These explorers, too, found a dry Salton Basin. As about 50 years were required to evaporate the water from this basin after the river ceased to discharge into it, there is, therefore, positive evidence that for over 450 years and probably for over 500 years the Colorado River has been flowing down the south slope of its delta cone. There is physical evidence, too, easily read, that in recent geological time the river has repeatedly changed its point of outfall from the Gulf to the Basin and back again to the Gulf. The following reference to the Salton Basin is found in the report of G. W. Blake, geologist of the transcontinental railroad survey, 1853:

"The present outflows, though but very slight, are probably similar (referring to Indian traditions of a great flood), and yet it is possible that the interior of the desert might be deluged at the present day, provided no elevation of the land has taken place and the river should remain at a great height for a long time—long enough to cause the excavation of a deep channel for New River."

The Indian tradition relating to the ancient lake is thus given by Dr. Blake:

"The great water (agua Grande) covered the whole valley and was filled with fine fish. There were also plenty of ducks and geese. Their fathers lived in the mountains and used to come down to the lake to fish and hunt. The water gradually subsided "poco poco" (little by little) and their villages were moved down from the mountains into the valley it had left. They also said that the waters once returned very suddenly and overwhelmed many of their people and drove the rest back into the mountains."

This ancient lake had a total length from northwest to southeast of 100 miles. Its northern limit was several miles above Indio and its southern margin was 15 miles south of the international boundary in Mexico. It has a mean width of 20 miles. The evaporation of this great body of water, after inflow ceased, caused the mineral contents of the water to be gradually carried to the lowest portion of the basin, where a crust of salts, mainly common salt, was left in sufficient quantity and of sufficient value to justify the establishment of salt works, which were operated for some years by the New Liverpool Salt Company.

It is within the area once covered by the ancient lake that all of the improved area of Imperial Valley lies. Calexico, at the Mexican boundary, is at sea level. Imperial, 12 miles farther north, is about 60 feet below sea level, and the cultivated lands near Brawley extend from about 100 to 200 feet below sea level.

At the northern end of the basin is Coachella Valley with Indio farthest north, and Mecca 190 feet below sea-level near the shore of the lake, when the lake was at its greatest extent in February, 1907.

And then there was another Indian tradition to the effect that the Colorado River flowed into a hole in the ground. The explanation of this tradition occurred to the author of this paper a few years ago and seems simple enough. When the Salton Sea was full, its surface extent was about 2,000 square miles. From this large area of water the annual evaporation was nearly 8,000,000 acre feet of water. This is one half of the normal annual discharge of Colorado River and more than the river's discharge in a year of light run-off. There were, therefore, probably periods of time sometimes exceeding a year in duration, aside from the filling period, when the Indian saw a river flowing into Salton Basin and saw no

water flowing out from this basin. What more natural than that he should assume a hole in the ground through which the river poured its waters into the bowels of the earth?

But of particular interest, because of its bearing upon the present discussion, is the main fact that periodically, say for a period of 500 to 1,000 years, the Colorado River had an outfall into the Salton Basin, that is, down the northern slope of its delta cone and again for a similar period of time the river has discharged into the ocean through the Gulf of California.

With this fact in mind let the boundary line be traced from the south boundary of Arizona following up the Colorado River for some 20 miles to Pilot Knob, and thence a little south of west in a straight line to the Pacific Ocean. This boundary line leaves a part of the Colorado River delta, Yuma Valley, in Arizona. It leaves the head of the Gulf of California and the main south slope of the river's delta cone in Mexico; and it leaves the major portion of the north slope of the delta cone, including what is now known as Imperial Valley and also the Coachella Valley, which was once deep under the waters of the ancient sea, in California.

From the earliest studies made of this region by citizens of the United States it is known that the Colorado River originally flowed from near Yuma to the Gulf of California in a meandering channel, having unstable banks, and inadequate capacity to carry all the water presented at flood stages. The distance in an air line from the head of the river's delta to the Gulf is in round figures 80 miles. In this distance the river falls 100 feet. It is about the same distance from the head of the delta to the lowest portions of Salton Basin but as the lowest part of the basin is over 280 feet below sea-level the fall in this direction is nearly 400 feet. If the river should be permitted to flow into the basin it would take 20 or 30 years to fill it up. There was no immediate danger of the river making a change in its course under the natural conditions that prevailed 50 to 75 years ago because at each flood stage the river banks were overtopped; they were well watered far back from the edge of the stream, and carried a luxuriant growth of trees, brush and grass and they were being constantly warped up by the sediment which the muddy water of the river spread out over the land.

But as soon as human activities modified these natural conditions, as soon as a small dredger cut invited the river down the steep northern delta slope, the river broke from its channel and temporarily abandoned its course to the Gulf. This happened in 1905 and it took a little more than a year to put the river back into its old channel. But while this was being accomplished the delta channels went dry. The vegetation on the parched bank land died out and fire destroyed the plant growth in large part which had, theretofore, protected the area nearest the river against erosion. And so, at the subsequent high stages of the river, there was more overbank flow and greater concentration of water in the swales leading away from the river and therefore increased danger of the river breaking out of its original channel. 1907 and 1908 passed without this happening, but in 1909 the river broke a new channel toward the west following the course of what was known as the Rio Abejas or Bee River. The point where this abandonment of the original river channel occurred was about opposite the south boundary line of Arizona.

The river has ever since, except for a few weeks while checked by a levee, been sending its water southwesterly in a round about way, through Volcano Lake and the Hardy Colorado into the Gulf. But its flow westerly was on or near the crest line of the river's very flat delta cone. Its channel is a broad shallow bed of sand of irregular alignment. At flood stages its water submerges broad stretches of country. Its flood waters would preferably drop off the delta cone to the north but have been prevented from doing this by levees. Herein lies the purpose of this statement of physical facts. The levees along the river and along the crest of its delta were and are required for the protection of property in the United States. All of Imperial Valley and of Coachella Valley are menaced. This does not mean that if a breach in the levees occurred and the river again discharged into Salton Basin that all of these valleys would be flood swept. Not at all. The river would simply

flow for a time into Salton Sea doing some damage but it would be turned back again toward the Gulf long before it could make any great headway toward filling the basin.

The interesting fact is that the levees which prevent the river from thus turning to the north and the great undertakings in 1906 and 1907 of turning the river from an erratic course back into its old bed, had to be done in foreign territory, and, moreover, without permission or sanction to do the work by any treaty arrangement. This will be explained by going back a little. When the Colorado River Land and Water Company (after reorganization the California Development Company) determined to put Colorado River water upon California lands it acquired a large tract of land in Lower California just south of and paralleling the boundary line. It organized in Mexico a subsidiary company, the "Compania de Terrenos y Riegos" and through the agency of this company constructed a few miles of canal from the boundary line, near the river, southerly and southwesterly, to a connection with a flood water slough known as Carters, or Salton or Alamo River. Meanwhile a diverting canal was constructed in California tapping Colorado River a few hundred yards north of the boundary line and leading into the upper end of the Mexican Canal. When water was turned into the canal in California it flowed to the Mexican Canal and thence to the Alamo channel and thence back into California. This became the nucleus of the Imperial Canal system. However, after a few years there was trouble at the head of the canal. Its upper section was too flat to pass all the silt entering from the river. And so in 1904 the Mexican Corporation made application to the Mexican Government for a water concession and the right to construct and maintain canals in Mexico. This was granted and provides that water may be diverted from the Colorado River in Mexico or may be brought into Mexico from California and conveyed across Mexican territory back into California, subject, however, to the condition that, to the extent of one half of the water in the canal, the landowners of Mexico shall have the right to use this water for irrigation.

When Imperial Irrigation District was organized and acquired the canal system of the California Development Company, it accepted the same subject to the conditions of the Mexican concession and for the purpose of doing work in Mexico it operates through its subsidiary, the Mexican Corporation.

It will be recalled that in 1909 when the Colorado broke from its channel into Bee River the Congress of the United States appropriated $1,000,000 to be used in protecting the Salton Basin against ultimate submersion. The Colorado River was to be turned back into its old bed and held there. As there was no treaty for the contemplated operations in Mexico, the President designated Mr. J. A. Ockerson to undertake the work. He in turn made the Mexican Corporation his agent and the work went on. It included not only the turning of the river but also the enlargement and extension of the levee north of Volcano Lake which has since become an increasingly important line of defense for the Imperial Valley.

When it is now considered that the control of the floods of the Lower Colorado will benefit about 800,000 acres of delta lands in Mexico and a somewhat larger area in California,—much of this, however, still in wild unimproved condition—the fact will be realized that there should be friendly consultation and cooperation between the United States and Mexico in order that the control of the lower river which must be put in a direct course to the Gulf and which must be kept there, may be placed in the hands of a competent agency, preferably the United States, and that arrangements may be made for reducing the flood menace by storing the waters of the Colorado at some point such as Boulder Canyon.

And then there is needed, too, some understanding between the two countries as to the quantity of water which will be allowed to flow into Mexico. It is probable that under regulation of stream flow by storage there will be enough water for all the lands in the two countries which may reasonably expect it. But practically all of the water which flows in the Colorado River originates in the United States and if the United States should choose to do so and physical conditions permitted, all of

the water could be withdrawn from the river for use within the United States. This will never happen, but negotiations in relation to this matter of giving definiteness to what Mexico may expect have already been too long deferred.

Not only is this the situation with reference to the irrigation use of water but immediate action in the matter of flood control is of paramount importance. On this phase of the problem only a word more need be said. Ever since the river changed its course in 1909 it has been depositing its load of silt, about 112,000 acre feet per year, in the Volcano Lake region. Drift and silt have filled depressions and choked old drainage channels. The first effect of the river's change in alignment was to depress the river's flood plane at the head of the Bee River six or seven feet and thence upstream by decreasing amounts to and above Yuma. But as the years rolled by and the warping up of the Volcano Lake regions has continued, the flood plane has been at a mean rate of about one foot per annum. Where no levee was required before 1908, to the north of the site of the lake (the lake itself has already been filled up with silt and obliterated) there is now a levee 14 feet high, with a railroad on top and with its water slope well faced with rock. And yet last year, 1921, the water at some points rose to the top of this levee. Attempt is now being made to coax the river into a more southerly course, but, even if this should succeed, the outfall of the flood waters will then be on a broad flat area which will quickly be filled to delta crest elevation and the same problem as the one of to-day will remain to be solved. The solution of this problem as already stated is comparatively simple when physical elements alone are considered. It is the international aspect which renders it complex. Action, at once, I repeat, by the United States is imperative.

It may be noted in this connection that about 70,000 people live in the area which is to be protected. Property values of $100,000,000 to $200,000,000 are involved. There are several hundred miles of railroads within the area that must be protected against the floods of the Colorado River.

In the matter of developing and putting to beneficial use the water resources of the Colorado River, it seems self-evident that the greatest ultimate good should be the main consideration. State lines cut but little figure in this matter. Opportunity by any state to divert and deprive earlier down-stream users of their water can carry no right to do so unless this be plainly in the public interest and unless it be done with due compensation for property values that are thereby destroyed.

It is wise, therefore, that steps have been taken for discussion of the river's problem as it affects the seven states within which the waters of the river originate. The Colorado River Commission is the medium for bringing these states into conference. What the outcome of this conference will be remains to be seen. Fortunately the production of water in the watershed of the river is so great that, despite all that can be done on its headwaters, to hold back and use the water locally, there will still enough water get by to make the storage on the lower river and the extension of irrigation in Arizona, California and Mexico desirable and economically feasible.

The development on the lower river is an interstate and international matter. It should be undertaken by the United States. The control of such a reservoir as that which is proposed for the Boulder Canyon site, for example, should never be relinquished to private interests whatever the agency by which the project is carried out. Boulder Canyon damsite is located on Colorado River just above the point where the river makes its abrupt turn from a westerly to a southerly course. It is some 60 miles in an air line above the point where California's east boundary line strikes the river and is but a few miles below the mouth of Virgin River. The Colorado River at this point forms the boundary between Nevada on the north and Arizona on the south. The canyon is narrow, being generally reported as about 250 feet in width for a distance of one half mile. The sides of the gorge are steep. The rock is granite. The project for storage at this site as now favored by the United States Reclamation Service involves the construction of a dam that would rise to a height of about

550 feet above the water surface of the river. The storage capacity of the reservoir to be created by such a dam would be in excess of 25,000,000 acre feet. The discharge of Colorado River at this point may be noted, in approximate figures, as ranging from 7,000,000 to 22,000,000 acre feet per year. The mean annual discharge may be about 15,000,000 acre feet. The surface area of the reservoir would reach 125,000 acres.

The feasibility of a dam of the dimensions proposed seems now to be generally accepted by the engineers who have investigated the dam site. A reservoir at Boulder Canyon would control the flow of Colorado River except the contributions by the Gila River, and the storage could be so manipulated that it would eliminate the lower river flood menace to the extent that this menace is due to up river high stages. Such a reservoir would also regulate the flow of the river for irrigation purposes, thereby permitting the extension of the irrigated area, and would generate upward of 600,000 horse power for electrical transmission.

It is not enough to know that this reservoir should be constructed. Equally important is the matter of urgency. And this applies with equal force to the reservoir control of the river and to the placing of the lower river upon a direct course to the Gulf.

C. E. GRUNSKY

PROGRESS IN POLYNESIAN RESEARCH

IN view of the many inquiries regarding the status of the anthropological studies in Polynesia, undertaken by the Bishop Museum, a summary statement of progress and results appears to be appropriate.

Systematic investigations of the origin and culture of the Polynesian peoples have been conducted by the Bayard Dominick Expedition and made possible by a generous gift of Bayard Dominick, Jr., of New York—funds given to Yale University and placed by the university at the disposal of Bishop Museum. During the summer of 1920 four field parties began their work—the first in Tonga, the second in the Marquesas, the third in Rurutu, Raivaivai, Tubuai and Rapa of the Austral Islands, the fourth in selected islands of the Hawaiian group. Through cooperative arrangements with scientists of New Zealand, physical measurements of the Maori and a complete survey of the Maoriori of Chatham Islands forms part of the program. By the end of this year all the field parties will have returned to Honolulu. These surveys supplemented by investigations in Tahiti and adjacent islands organized for 1923, will complete the present plans of the Bayard Dominick Expedition. Contributions to the physical anthropology of Samoa and of Tonga have been published by the museum; other papers are in press or in preparation for publication.

The prosecution of this search for Polynesian origins aims at the solution of two distinct problems: (1) the source of the physical racial characteristics, which have combined to make the Polynesian physical types; and (2) the source of the original elements which formed the basis of the ancient culture of the people. Dependent upon the solution of these is a third problem: the degree in which racial and cultural transplantation and stratification are correlated.

Dr. Louis R. Sullivan, physical anthropologist of the American Museum of Natural History, is devoting himself to the study of the racial data secured by himself and by other members of the expedition. He makes the following tentative classification of the physical characters which go to make up the two basic elements in the Polynesian peoples:

Type 1 is characterized by (1) tall stature, (2) moderately long heads, (3) relatively high, narrow faces, (4) relatively high, narrow noses, (5) straight or wavy black hair of medium texture, (6) well-developed moustache and moderate beard on the chin, (7) moderate amount of hair on the body and limbs, (8) light brown skin, (9) incisor rim present occasionally, (10) femur flattened (platymeric), (11) tibia flattened (platycnemic), (12) ulna flattened (platolenic), (13) lips above average in thickness. Type I is the so-called Caucasoid element in Polynesia; sometimes spoken of as Pseudo-Caucasian or Pseudo-Mediterranean. Macmillan Brown regards it as Nordic. In its characteristics it is intermediate between some

Caucasians and some Mongols. It may eventually prove to be a very primitive Caucasoid type, probably related to primitive inhabitants of Micronesia, Indonesia, and to the Aino and some of the primitive American Indians. It is probably the oldest type in Polynesia (except where it was possibly preceded by the Melanesians), and it occupied all of the Polynesian Islands. At present it seems to be strongest in the southern part of Polynesia.

Type II is characterized by (1) shorter stature, (2) shorter heads, (3) low, broad faces, (4) low, broad noses, (5) wavier hair, (6) undeveloped beard, (7) body hair rare except on the legs, (8) darker brown skin, (9) incisor rim rare, (10), (11), (12) long bones less flattened (data meager, results inferred), (13) lips well above the average in thickness. Type II is the element so often referred to as Malay, and is undoubtedly the one which has been traced to the region of the Celebes by linguists and ethnologists. Malay is not a suitable name for it, since it is usually restricted to groups more definitely Mongoloid. It approaches somewhat closely Giuffrida-Ruggeri's Indonesian type. This element has contributed some of the negroid characteristics (full lips, dark skin, broad flat noses), usually attributed to Melanesian mixture. The type is strongest in northern and central Polynesia.

Edward S. Handy, ethnologist of the Bishop Museum staff, and a member of the Dominick Expedition to Tahiti and the Marquesas in 1920-21, has come to the following conclusions with regard to the general ethnology of Polynesia.

There is a basic Polynesian cultural complex, some of the most important elements in which are: (1) cooking by means of heated stones in ground ovens; (2) the use of stone pestles for pounding food; (3) the use of wood, gourd, and cocoanut shell, rather than pottery, for containers; (4) skillful woodworking and carving; (5) tattooing; (6) the making of tapa, or bark cloth; (7) a characteristic relationship system; (8) the customs of adopting and betrothing children; (9) systematic agriculture and fishing, taro and potato cultures; (10) professional craftsmanship and leadership in industry; (11) tribal government of simple patriarchal communism; (12) preserving heads of enemies as trophies, and cannibalism; (13) ancestor worship, the preservation of genealogies, and the hiding of skeletal remains; (14) inspirational diviners; (15) a speculative creation mythology conceived on the principle of dualism, expressed in terms of male and female agencies. This complex was universally distributed throughout Polynesia; but it is most clearly to be distinguished in the historic cultures of New Zealand and the Marquesas, both of which groups may be characterized as outposts. These elements being universal, and best preserved in the marginal region, may be taken to represent the primitive, in the sense of original, Polynesian culture. This we may call Culture A.

Superimposed on this original culture are certain other elements, some of the most important of which are: (1) organized government; (2) a rigid social classification; (3) complicated systems of land division and ownership; (4) great sacredness of chiefs and elaborate etiquette; (5) organized dancing as a social and religious institution; (6) organized religious ceremonial and priesthood; (7) a generation cult and seasonal rites; (8) haruspication. As compared with Culture A, this culture appears to have been characterized by a higher social and religious, rather than higher technical, development. This group, with other associated elements, too numerous to include here, may be called Culture B.

It is possible that the elements in Culture B may have resulted by a natural evolution from the primitive Culture A. But it is far more probable that they represent the culture of a second immigrating wave of a people, closely related culturally to those of the first wave. Churchill's analysis of the language led him to the conclusion that the dialect spoken by the second wave of migrators to Tonga and Samoa was very closely related to that of the original settlers.

A study of Polynesian ethnology recently completed by Ralph Linton indicates that the material culture of the Marquesans and related groups support entirely the theory of an original culture and later overlay. The more important elements which his study adds to the classification given by Dr. Handy are: to Culture A, (1) a rectangular house with end

posts and bed-space; (2) a canoe made of five parts; and (3) the tanged adze; to Culture B, (1) the oval house; and (2) wooden head rests and utensils with legs.

It is interesting to note that the basal Polynesian physical type (Type I), as worked out by Sullivan, is universally distributed, but strongest in the south, and the original culture (Culture A), also universally distributed, is clearest in the south (New Zealand) and east (the Marquesas). Also physical Type II is strongest in north and central Polynesia, the same region in which elements in Culture B are dominant. This demonstrated parallelism of racial types and cultural stratification rests on conclusions arrived at independently by members of the museum staff working in widely separated fields with no opportunity for consultation. It is regarded as a very important contribution to the attack on the Polynesian problem. Another contribution is the definition of characteristics and elements belonging to the respective types and cultures—a prerequisite to comparative studies.

As regards the sources of these racial types and cultural elements and the routes by which they came to Polynesia, the evidence in hand indicates the region of the Malay archipelago (Indonesia) and southeast Asia as that from which the Polynesian ancestors commenced their eastward drift. Whither, beyond that region the search for ultimate origins may lead, can not be foreseen. The writing of the earliest chapters in the history of the Polynesians and of other Pacific races must await the definition of ancient and modern Asiatic types and cultures and the determination of early stages revealed through archeology.

The work of the acheologists of the Bayard Dominick Expeditions revealed no very ancient human habitation in the central and south Pacific. For the Polynesian settlement the evidence serves to substantiate the conclusions of William Churchill, based on linguistic and cultural study. The following dates are considered reasonable estimates: A.D. 0, the first Polynesian migratory movement; A.D. 600, a second migration; and A.D. 1000, a period of great Polynesian expansion. According to S. Percy Smith and other Maori scholars, New Zealand was already in possession of original settlers by the tenth century although the main Maori migration did not occur until the thirteenth and fourteenth centuries. Dr. Handy has concluded that the Marquesas Islands were first settled in the tenth century or slightly earlier, and Fornander presents good reasons for the belief that the original settlers of Hawaii experienced the coming of a migratory wave at the beginning of the eleventh century.

At least three general routes of migration appear to have been used through Indonesia: (1) along the coasts of New Guinea, (2) through Micronesia, (3) through and along the marginal region east of Melanesia.

Two years of organized study has shown that the history of Polynesia is fundamentally a field problem and that progress depends upon the accumulation of facts by trained students.

HERBERT E. GREGORY,
Director
BERNICE P. BISHOP MUSEUM

SCIENTIFIC EVENTS

A FOREST UNDER THE CITY OF WASHINGTON

EVIDENCE of the existence of an ancient swamp in which great trees flourished in days long past, possibly contemporaneous with earliest man in America, has been discovered in a deep excavation made for the foundation of a hotel under construction in Washington, D. C. At a depth of about twenty-five feet below the street level the excavation disclosed a layer of black swamp muck, containing large quantities of wood, tree trunks and stumps. Some of the stumps are of great size, a few of them reaching a diameter of nine or ten feet. Much of the wood is well preserved, showing clearly the woody structure and the external markings of the bark. A preliminary examination indicates that one of the more common trees of this ancient swamp was cypress.

The story of these trees, however, is only a brief chapter of the whole geologic history shown in the excavation, which has just been examined by Chester K. Wentworth for the

United States Geological Survey. Ages ago this part of the Atlantic Coastal Plain was from time to time covered by the sea, into which streams swept vast quantities of mud, sand and gravel and boulders which formed thick deposits that covered large areas. When the region finally emerged from the sea the Potomac River cut its valley in these deposits, which were carried about here and there also by smaller streams. The larger boulders are derived from the granite on which the gravel lies, but some of the smaller pebbles come from parts of the Potomac basin beyond the Blue Ridge and others from veins of quartz in the granites of the Piedmont Plateau.

Over the layer of plant débris and muck in this old swamp fine clay and pebbles were laid down by streams of water during the glacial epoch, when the northern part of North America, as far south as northern Pennsylvania, was covered with immense sheets of thick ice, showing that the trees lived in the latter part of the Great Ice Age, which is variously estimated to have ended from 20,000 to 30,000 years ago.

OPPOSITION TO EVOLUTION IN MINNESOTA

IT was reported in SCIENCE last week that at a conference in St. Paul, Minn., of pastors representing Baptist, Congregational, Presbyterian and Lutheran churches, it was decided to issue a call for a state-wide meeting of Protestant ministers to oppose the teaching of evolution in the public schools of Minnesota.

At this meeting, which was held on October 26, the following resolutions were passed:

Preamble—As American citizens we believe in the complete separation of church and state, and are opposed to religious teaching in public schools—higher or lower.

As those who wish to teach Christianity must support their private schools, we believe it but just that those who wish to teach anti-Christian theories should be forbidden the use of tax supported schools for propagating their opinions.

Whereas, The evolutionary hypothesis has come to be accepted by many American teachers, and is increasingly taught in the public schools of Minnesota, including high schools, our state normals and state university, and

Whereas, This hypothesis, after sixty-three years of study, remains wholly unproven, and has increasingly shown itself to be a foe to the Christian faith, denying as it does the veracity of the Scriptures,

Therefore be it resolved, That we, citizens of Minnesota, representing thousands of our fellow citizens, hereby utter our protest against this propaganda of infidelity, palmed off in the name of science, and we call upon the trustees of state institutions to demand of teachers a cessation of such teaching and the removal from our schools of such text-books as favorably present the same.

We do this in the interest of true science *vs.* science falsely so-called; and in the interest of fair dealing.

We hold that the first amendment to the constitution of the United States, "Congress shall make no law respecting an establishment of religion," was never intended to be interpreted that the state should become sponsor for irreligion; and that it is manifestly unfair to impose taxes upon Christian taxpayers to inculcate teaching inimical to the Bible and destructive of civilization itself.

We have waited patiently for this hypothesis to either prove a truth or to pass from public instruction. Having now no prospect of either, we demand that the state shall prove its impartiality toward its citizens by dispensing with a subject that is utterly divisive; and is, in the judgment of thousands of its taxpayers, utterly false.

And we declare that if the school authorities prove derelict in the enforcement of the law relating to the teaching of religion or of theories subversive of the Christian faith, we will appeal to the legislature for the enactment of such laws as shall eliminate from our tax-supported school system this antiscientific and antiscriptural theory of the origin of man and the universe.

THE ADMINISTRATION OF THE UNITED STATES GEOLOGIC SURVEY

ON November 15, David White completes ten years service as chief geologist. This contribution to the administration of the survey has been at the expense of his own scientific work, even though he has thereby increased the scientific value of the work of his associates. It seems fair that his oft-repeated request for permission to return to his own geological studies should now be granted, not only to gratify the natural desire of an investigator

who has laid aside research problems, one after another, but also to promote the advancement of our science.

Effective November 16, W. C. Mendenhall, for more than ten years the geologist in charge of the Lang Classification Board, will be chief geologist. Mr. Mendenhall's twenty-eight years service in the Survey as assistant geologist and geologist, with field experience extending from the Southern Appalachians to Alaska, is a promise of his broad sympathy with all the problems that will come under his direction, and his notable success in using the data contributed by the field branches in the classification of the public-lands is equally a promise of effective administration.

Mr. Mendenhall will be succeeded as chief of the Land Classification Board by Herman Stabler, his close associate in that branch during the past decade. Mr. Stabler's demonstrated capacity both in research and in administration assures the continuance of the successful application of geologic and engineering facts and principles to public land administration.

The return of Mr. White to productive research suggests anew the sacrifice involved in the administration of scientific work. Administration by scientists is the key-note of the Survey's policy, yet the intellectual cost item involved in this drafting of our best investigators must be kept down to a minimum. Had I been free from other demands on my time this past summer, I should have taken this occasion to start a somewhat radical reorganization of the Geologic Branch, the chief purpose of which would be to reduce its administrative overhead—too many geologists are giving valuable time to work for which they were not trained. Necessarily now, this task of simplifying the organization must be left to the new chief geologist and the acting director, but I ask for them a sympathetic acceptance of the proposal for a less elaborate but more elastic grouping of the activities of the branch. Not machinery but product is the measure of efficiency in a government scientific bureau.

GEO. OTIS SMITH,
Director

THE NEW BUILDING OF THE NATIONAL ACADEMY OF SCIENCES AND THE NATIONAL RESEARCH COUNCIL

ON the afternoon of Monday, October 30, the cornerstone was laid of the new building of the National Academy of Sciences and of the National Research Council at Washington, D. C. This building, construction of which has now been carried above the main floor, occupies a desirable location upon an entire block of land north of the Lincoln Memorial at the western end of the Mall, commanding an excellent and permanent view of the Memorial, the Riverside Park and the bank of the Potomac beyond. The land for this building was purchased through contributions from a group of twenty friends of science.

The building is designed for two main purposes: To house the offices of the two organizations for which it is erected, and to provide space for the exhibition of materials representing certain of the great achievements of science in the past and especially of recent contributions of particular significance in the progress of science. The building presents a façade to the southward 260 feet in length, and will rise to a height of 60 feet above the first floor. In this section there will be three floors for offices, library and special exhibits rooms. Behind this will be a rotunda for general exhibition purposes which will be convertible at need into a lecture room accommodating, with its galleries, over 400 people. The plans permit the addition of other units similar to the southern façade, to complete a quadrangle around the rotunda. The building is being faced with white Dover marble of fine quality and color which makes it in keeping with the other monumental buildings of the city. The cost of the unit at present under construction will be over $1,000,000. The funds for the erection of the building were provided by the Carnegie Corporation of New York.

The laying of the cornerstone was a ceremony of the simplest kind without the presentation of any addresses. It was attended by officers and members of the academy and of the Research Council, among whom was the Honorable Herbert Hoover, secretary of commerce.

The stone, itself, bearing the date "1922" and the initials "N. A. S." and "N. R. C.," occupies a position high in the wall of the first story at the southwestern corner of the building. Within a copper box in the stone were placed significant documents connected with the founding of the National Academy and of the Research Council and lists of the members of both organizations. It is expected that the building will be ready for occupancy in the fall of 1923.

SCIENTIFIC NOTES AND NEWS

THE National Academy of Sciences will hold its autumn meeting in New York on Tuesday, Wednesday and Thursday, November 14-16, 1922. The meetings on Tuesday will be at Columbia University, and, so far as possible, papers from the sections of astronomy, chemistry, geology and paleontology will be assigned to this day. On Wednesday the meetings will be at the Rockefeller Institute, with papers from the sections of botany, zoology and animal morphology, physiology and pathology, and anthropology and psychology. On Thursday the meetings will be in the auditorium of the United Engineering Societies Building with papers from the sections of mathematics, physics and engineering. The local committee for the meeting consists of J. F. Kemp, *chairman*, T. H. Morgan, Simon Flexner, J. J. Carty, F. B. Jewett and F. M. Chapman.

THE Henry Jacob Bigelow medal of the Boston Surgical Society was presented to Dr. William W. Keen, of Philadelphia "for conspicuous contributions to the advancement of surgery," on the evening of October 25, when Dr. Keen addressed the society on "Sixty years of surgery, 1862-1922."

MEMBERS of the faculty and alumni of the University of Chicago recently contributed a fund for a portrait of Professor A. A. Michelson, who for thirty years has been head of the department of physics in the university. The portrait has been completed by Ralph Clarkson.

ON the occasion of the celebration of the fiftieth anniversary of the Dutch Zoological Society there were admitted as honorary members: Professor O. Abel, Vienna; Professor M. Caullery, Paris; Professor L. Dollo, Brussels; Professor B. Grassi, Rome; Professor V. Häcker, Halle; Professor S. J. Hickson, Manchester; Professor N. Holmgren, Stockholm; Professor T. H. Morgan, New York; Dr. F. Sarasin, Basle, and Dr. J. Schmidt, Copenhagen.

THE British Institution of Mining and Metallurgy has awarded its gold medal to Sir Alfred Keogh, "on the occasion of his retirement from the rectorship of the Imperial College of Science and Technology, in recognition of his great services in the advancement of technological education."

DR. GEORGE OTIS SMITH has resigned the directorship of the United States Geological Survey, in order that he may qualify legally as a member of the United States Coal Commission. It is understood that the President hopes that Dr. Smith will be willing to resume his work as director of the survey when his service as member of the coal commission comes to an end.

WE learn from *Nature* that Mr. E. Leonard Gill has been appointed to fill the vacant assistantship in the Natural History Department of the Royal Scottish Museum, Edinburgh. Mr. Gill has already had museum experience in Leicester and Manchester, and for almost twenty years has been in charge of the Hancock Museum at Newcastle-on-Tyne.

MR. T. RUSSELL GODDARD, assistant curator at the Sunderland Museum, has been appointed curator of the Hancock Museum, Newcastle-upon-Tyne.

DR. C. R. ORTON, plant pathologist at the Pennsylvania State College, has been appointed a member of the division of biology and agriculture of the National Research Council.

THE board of managers of the Wistar Institute has elected Dr. J. A. Detlefsen to a professorship for the duration of his sabbatical year as a courtesy and to make possible the continuation of investigations carried on at the College of Agriculture of the University of Illinois.

DR. SELIG HECHT, national research fellow in chemistry, has been appointed research fellow in physical chemistry at the Harvard Medical School, where he will continue his investigations.

PROFESSOR WILLIAM A. RILEY, chief of the division of entomology in the University of Minnesota, returned in September from a three months stay in Porto Rico, where he made an intensive study of the relation of soil conditions to the propagation of parasites.

PROFESSOR ELIAS J. DURAND, of the department of botany of the University of Minnesota, is on leave this year because of ill health.

DR. W. W. STIFLER has accepted an appointment from the China Medical Board of the Rockefeller Foundation and the trustees of Canton Christian College as visiting professor of physics at Canton Christian College for the academic year 1922-1923. Mr. Stifler has been associated with the Peking Union Medical College, since its reorganization in 1917 by the China Medical Board, as head of the physics department and dean of the Premedical School in Peking. After his year in Canton he expects to return to the United States.

DR. ARTHUR BLISS DAYTON, associate in medicine at the Yale School of Medicine, has been given a year's leave of absence to serve as professor of medicine at the Medical School of Yale-in-China. Dr. and Mrs. Dayton are now in Changsha.

DR. G. R. BISBY has returned to the Manitoba Agricultural College, Winnipeg, after a year with the Imperial Bureau of Mycology, Kew Gardens, England.

ISSEI YAMAMOTO, assistant professor in the Kyoto University Observatory, Japan, has recently received appointment as volunteer research assistant in the Yerkes Observatory. He has been sent to the United States by the Japanese government to spend about a year in several of our observatories.

DR. LUDWIK SILBERSTEIN, of the Research Laboratory of the Eastman Kodak Company at Rochester, N. Y., addressed the Franklin Institute of Philadelphia on November 2, on "The spectrum of neutral helium and the behavior of its two electrons."

DR. AUGUST KROGH, professor of physiology at the University of Copenhagen and Silliman lecturer at Yale University, will deliver the second Harvey Society lecture, at the New York Academy of Medicine, on Saturday, November 11, on "Nervous and hormonal control of capillary contractility."

IN continuation of the series of evening lectures given in the spring and fall in the administration building of the Carnegie Institution of Washington, 16th and P Streets, Washington, D. C., a lecture was given on November 7 by Dr. C. G. Abbot, collaborator of the Mount Wilson Observatory and assistant secretary of the Smithsonian Institution, on "The heat of the sun and other stars." On November 21 Dr. Louis A. Bauer, director of the Department of Terrestrial Magnetism, will give a lecture on "The greater problems of the earth's magnetism and electricity, and their bearings in astronomy, geology and physics." Three additional lectures will be given on succeeding Tuesday evenings, announcements of which will appear later.

PROFESSOR Z. B. JEFFERY delivered a lecture on October 9 on Einstein's theory of relativity, at King's College, London, as an introduction to a course of twenty-five lectures to be given at the college on "The Mathematical Theory of Relativity."

AS noted in SCIENCE recently the exercises in connection with the dedication of the Sterling Chemistry Laboratory will be held on Wednesday, April 4, 1923. This date is the anniversary of the first lecture in chemistry at Yale by Professor Benjamin Silliman on April 4, 1804.

LADY LOCKYER and Miss Lockyer are preparing a biography of Sir Norman Lockyer, the distinguished astronomer and editor of *Nature*.

THE unveiling of the tablet in memory of the late Professor Sir William Ramsay, K.C.B., F.R.S., in Westminster Abbey by the Prince of Wales, as patron of the Ramsay

Memorial Fund, took place on November 3. Afterwards, in the Jerusalem Chamber, the French ambassador, the Count de Saint-Aulaire, as one of the vice-presidents of the fund, presented to the prince the Ramsay Memorial Gold Medal, which has been executed by the French sculptor, Monsieur Bottee.

ROBERT WHEELER WILLSON, professor of astronomy, *emeritus*, at Harvard University, died at his home in Cambridge on November 1, in the seventieth year of his age.

DR. C. W. WAGGONER, head of the department of physics in West Virginia University, has died from the effects of a fall from a horse, at Shreveport, Louisiana.

FRANK SHERMAN WASHBURN, chairman of the board of directors of the American Cyanamid Company, a leader in American engineering, died at his home in Rye, N. Y., on October 9, aged sixty-two years.

PROFESSOR C. MICHIE SMITH, government astronomer of Madras, 1891-1911, and director of the Kodaikanal and Madras Observatories, 1899-1911, died on September 27.

J. K. A. WERTHEIM SALOMONSON, professor of neurology and radiology in the University of Amsterdam, has died at the age of fifty-eight years.

THE death is announced, as the result of an accident while on holiday in the Alps, of Herr Leo Madrnozka, professor of electrical engineering at the Technical High School, Munich.

THE speakers who are expected at the Pasteur celebration of the New York Academy of Medicine are: Professor Russell H. Chittenden, Dr. William H. Welch, Dr. Erwin Smith, Dr. Simon Flexner, Dr. Herman Biggs and Dr. W. W. Keen. The exhibition of books, photographs, medalions, manuscripts, etc., referring to the life work of Pasteur, is to be open to the public at the New York Academy of Medicine, 17 West Forty-third Street, New York, for two weeks, commencing December 27, 1922. The public addresses are to be given at the academy on the evening of January 10, 1923. Any one having souvenirs or memorabilia connected with Pasteur's work is invited to loan them for the academy exhibition, and address, for this purpose, the librarian of the academy, Mr. J. S. Brownne.

THE National Committee for Mental Hygiene was engaged during August, September and October in making a mental hygiene survey in North Dakota. This is one of several state surveys being conducted by the national committee. Recommendations are made to the governor and legislature for appropriate action. Those conducting the North Dakota survey were: Dr. Thomas H. Haines, consultant for the National Committee for Mental Hygiene, director; Dr. Ward G. Reeder, assistant professor of school administration in the Ohio State University; C. L. Hultgren, psychologist for the national committee, and Mina A. Sessions and Lucille Martin, psychiatric social workers for the committee.

UNIVERSITY AND EDUCATIONAL NOTES

THE departments of civil engineering and electrical engineering of the South Dakota State School of Mines have been transferred to the new building erected for them, for which the legislature made appropriation of $130,000 for building and $15,000 for furnishing. Additional funds were provided for machinery and apparatus.

MR. AND MRS. LEON E. SCHWARTZ have given $20,000 to the School of Medicine of Tulane University for the establishment of the David Trautman Schwartz Research Fund.

THE directors of the University of Cincinnati have received a letter from the chairman of the General Education Board, asking that action taken to name a chair in the College of Medicine after John D. Rockefeller be deferred because of Mr. Rockefeller's objection to such a course. The communication said that "Mr. Rockefeller would prefer to have his name recorded in the hearts and lives of those using the improvements which donations from him have made possible rather than having it carved in stone or officially connected with the building."

DR. MANFRED CALL, formerly professor of clinical medicine, has been elected dean of the medical department of the Medical College of Virginia, at Richmond.

DR. H. M. JENNISON, for several years assistant professor of botany at the Montana Agricultural College, Bozeman, has become associate professor of botany in the University of Tennessee.

ANDREW KARSTEN (Ph.D., University of Ohio), has recently entered upon his work as head of the department of chemistry at the South Dakota School of Mines.

FREDERICK P. VICKERY, formerly of Leland Stanford, Jr., University, has been appointed assistant professor of geology and head of the department at the Southern Branch of the University of California, at Los Angeles.

DISCUSSION AND CORRESPONDENCE

STELLAR DIAMETERS

THE determination of star diameters has been a matter of considerable interest since the first measures of *Betlegeuse* were published from the Mount Wilson Observatory. Various predictions have been made for the apparent diameter of stars by Eddington, Russell, Wilsing and Hertzsprung, based directly or indirectly upon visual estimates of brightness, color and spectral type. The recent work of Coblentz at the Lowell Observatory has afforded means of determining new curves of spectral intensities giving data for a revised correlation of temperatures and spectral types. Such information, together with the direct thermo-electric measures of stellar radiation made by Coblentz both at the Lick and the Lowell Observatories, affords the basis for the calculation of a star's surface area if its distance is known, or, wanting accurate parallax determinations, the apparent angular diameter can be computed on the grounds of black body radiation. This serves at least as an independent method of checking star diameters, and the results of its application to the three stars whose diameters have thus far been measured by the interferometer method may be of general interest, and are given below:

STAR	DIAM. FROM COBLENTZ' DATA	MT. WILSON MEASURES	PREDICTED DIAMETERS	
			Eddington	Russell
α Orionis (Betlegeuse)	0.045″	0.047″	0.051″	0.031″
α Scorpii (Antares)	0.036″	0.040″	0.043″	0.028″
α Bootis (Arcturus)	0.018″	0.022″	0.020″	0.019″

The agreement between the diameters computed from the galvanometer deflection determined by Coblentz (*Sci. Papers Bureau of Standards,* Nos. 244, 438) and the actual measured diameters is surprisingly good. It is not easy to suppose that a star can radiate as a black body. Since, however, this assumption is fundamental in applying the laws of radiation from which the diameter is computed, it is rather remarkable to find stars radiate as nearly like black bodies as the bit of evidence herein contained would seem to show.

H. T. STETSON
HARVARD UNIVERSITY,
ASTRONOMICAL LABORATORY

TINGITIDÆ OR TINGIDÆ AGAIN

"To be or not to be"—*Tingitidæ* or *Tingidæ*? Logomachy is a "war about words." It seems that I have involved myself in such a merry war, driven thereto by my desire as a scientific editor to get at the bottom facts as to what is the correct scientific family-name to give to those insignificant, but very interesting and beautiful little creatures, commonly known as "lace-bugs." In a little article published in SCIENCE (N. S.), LVI, 1922, pp. 334-335, I found in favor of the family name *Tingitidæ*. Now comes that excellent entomologist, Professor H. M. Parshley, of Smith College, and reminds us that in an article published in *Psyche,* XXIII, 1916, p. 129, he had found in favor of *Tingidæ*. His argument in brief is founded upon the statements:

1. "We can not be sure that Fabricius did in fact adopt the Greek word Τίγγις, the name of a city."

2. "His use of the genitive *Tingis* [in a footnote] shows us that he considered the word his own and indicates what its Latin declension should be."

I regret that I had completely overlooked Professor Parshley's article, and duly apologize for the oversight. I am, however, con-

strained to state in brief that what he says does not carry conviction to my mind.

As to his first postulate I may indeed say that "we can not be sure" of anything. Fabricius has been dead for over a century, and not even through Sir Oliver Lodge or Conan Doyle can we get into touch with him and ascertain definitely what he was thinking about when he first coined the generic name we still use. But we do know that he had the *habit* of coining generic names from those of ancient towns and cities. The word *Tingis* had been in existence two thousand years before Fabricius was born and in its Greek form Τίγγις and in its Latin forms *Tingi* or *Tinge* could be found in any dictionary Fabricius might have consulted. The word was no more "his own" than hundreds of other words he used in his writings. It is difficult for me to believe that Fabricius out of the depths of his subconscious mind fished up an altogether arbitrary combination of letters, *T-i-n-g-i-s*, making out of them, as Professor Parshley says, "his own word." The nomenclatorists of the time of Fabricius had not yet reached the stage attained at a later date by some of their successors, who took random combinations of letters and then by various transpositions and combinations manufactured words without meaning, which they employed for generic and specific terms. Fabricius was a disciple of the old Linnean school and used the Latin language. I question whether he had a sense of "proprietorship" in words.

The fact that he employs *Tingis* as the genitive only shows that he thought that this was the genitive, after the analogy of some other words in the Latin language, and that he did not take the trouble to ascertain what was the true declension of the noun he was employing. *Humanum est errare.* The genitive of the Latin noun *Tingi* or *Tinge* (the equivalent of the Greek Τίγγις, must have been *Tingitis,* as shown by the adjectival form *tingitanus,* used by Pomponius Mela, Claudius Mamertinus, *et al.* Fabricius simply made a slip in his declension, which it was easy enough to do.

With all due respect to the conclusions of Professor Parshley I contend that we are dealing with an old Latin word (found also in the Greek, where it has an *i-stem*) and that *Tingitidæ* is the correct form of the family name, sanctioned by the use of such eminently capable scholars as Stål (by the way, an excellent linguist), Champion, Oshanin, Horvath, Osborn, Drake and a multitude of others.

W. J. HOLLAND

CARNEGIE MUSEUM,

A MINIATURE PHOTOGRAPHIC DARKROOM

NECESSITY has mothered many an inspiration. This trite exclamation was brought to mind by the sudden need of providing darkroom facilities when our commodious attic quarters were closed in order to lessen fire risk. Two alternatives suggested themselves, either to partition off a corner of a room or to construct a portable light-proof developing box. Past experience with small stuffy darkrooms was recalled, and the writer accordingly undertook to build a dark box as a venture. The convenience of this box, its adaptability to many photographic purposes, and the successful results following its use have led to the publication of this announcement in the hope that others, at present deterred from attempting photography through lack of facilities, may find that the way is easily open.

This miniature darkroom is constructed of pressed wood-pulp board nailed over a light wooden frame. Dimensions of 36 inches for width 24 inches for depth and 20 inches for height have proved to be entirely satisfactory. At the lower part of the front face an opening of about 24 by 10 inches admits the arms and hands of the operator. This opening is rendered light-proof by two thicknesses of close-woven black sateen cloth continuous with two sleeves. By having the cloth considerably larger than the opening and shirring the edges, free movement of the arms is afforded by the bulging central portion. The ends of the sleeves are made close fitting by elastic bands. Black sateen bloomers can be bought ready made and are of the exact pattern and size, with shirring and elastic fittings ready for attachment to the box. Because of looseness of weave, two superposed layers of cloth should be used.

The top of the box has a removable light-

tight cover. This is made possible by tacking a tongue of half-inch stripping around the edge of the cover to fit into a trough at the top of the walls. The tongue and trough are painted matt black, a little lampblack in weak alcoholic shellac answering for this purpose. The interior of the box need not be painted, although a white coat affords a better view of manipulations in the interior.

To view what is going on inside the box two small windows are provided at the level of the eye when the box is set on a table. The window in front is of clear ruby photo-safe glass, the one opposite is either of ruby glass or translucent ruby fabric. Behind the rear window is placed an electric bulb operated by a switch inside. Another inside switch controls a socket on one wall which may interchangeably have a low candle-power light for lantern slide making or a high power light for exposing development papers. A shelf located midway across the end is an added convenience. The entire cost for materials is five dollars; a few hours of labor can construct the box.

A secret of continued success in using this small darkroom is to keep hypo away and thus avoid contamination. This is possible by having a tray containing weak acetic acid, about 2 per cent., into which is to be immersed plates, slides, films or prints as fast as they are developed. The acid checks the action of the developer and permits the quick removal of the light-sensitive materials from the developing box to the hypo bath outside without danger of fogging. Developed material can be left in the acid bath until it is convenient to open the box.

The idea of a developing box is not new. There are small developing tanks and boxes on the market for daylight use by the time method of development. Convenient changing bags of cloth have long been employed by the traveler. Developing boxes equipped with sleeves and ruby glass are available with X-ray outfits. Undoubtedly the urgency of the war period for rapid photographic production led to the construction of portable darkrooms. But the simplicity, adaptability and convenience of the above-described miniature darkroom are so great that the writer will be pardoned, even though his discovery is not new, if this announcement will acquaint others with a worthwhile piece of equipment.

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THE VALUE OF COST ACCOUNTING IN ANALYTICAL AND CONSULTING LABORATORIES

THIS subject has had very little, if any, consideration in the past. The probable reason for this neglect appears to be the comparatively small field for analytical and consulting laboratories.

Through the long association with this field the writer has worked out an elaborate system of cost records which have proved most valuable in the determination of a fair price to clients as well as a fair return to the owners. This system produces such information as will show what work is profitable and what kinds of analytical tests are unprofitable; the reasons for the profits or losses are readily revealed after a persistent tabulation of the records.

The latter information serves to permit the preparation of sliding scale prices, *i. e.*, for one test, for two tests, for three tests, etc. It also reveals the comparative fluctuations in the costs on a given test. This variation in costs should always be treated with the utmost care, as when a worker becomes so proficient that he does not require the assistance of any of the usual factors in a laboratory, and finishes the job in record time, the owner as well as the client is entitled to a little of this efficiency in dollars and cents. The owner should weigh the costs in these cases against the reasons why that worker is proficient in making these certain tests and allow himself leeway for either the replacing of that man or the increasing of his salary. An efficient and speedy worker generally secures his knowledge by repetition principally, by use of the owners' books and the supervision and advice of his chiefs. In other words, the speed and efficiency of one worker is not the only basis for costs.

The costs when compiled in a comparative form will readily show the variations, the causes being numerous. Some of them are represented in the unfamiliarity with the

methods of analysis, the necessity of preparing the apparatus for the work, the difference in wages and the necessity for accuracy and not speed. The latter case appears when there is a legal matter involved and several repeat tests are made.

The costs are primarily based on the productive amount. Between the period when a worker starts his job and when he finishes it his time is estimated and placed on a card. Each day he completes a Daily Time Report, filling in the laboratory number, work done and the estimated time required. It is impossible to accurately determine the amount of time spent on the job, as from start to finish. The reason for this being the number of jobs a worker can do at one time, namely, start one and get that job in a condition where it will work while he is away from it, in the meantime, start another, watching both at the same time.

After the worker fills in his card it is approved by the man in charge and sent to the accounting department daily. The department chiefs and assistants are given cards which permit them to record their time from start to finish. The nature of their work, which consists mainly in consultation work, permits a recording of their time accurately.

The time cards of both the workers and chiefs are then summarized by the addition of the per hour rate, and the amounts chargeable to any particular job are entered on a cost-ledger card.

The productive amount as shown on the cost ledger card is increased by its proportionate share of the overhead as determined by the distribution of overhead. Materials used are so small in comparison with the other factors that to determine the amount used on each job would cost more than the results would warrant. The total amount of materials used, as determined by a check against the inventory on the yearly basis, is charged directly into the overhead.

In the beginning it is necessary to appraise the inventory as accurately as possible, also the location of the various items as to departments. The space occupied by each department must be known so as to properly distribute the rent charges. The question of insurance can be distributed according to its risk, *i. e.*, fire—on the basis of the inventory.

The value of this work is evidenced in more than one direction. It presents a basis for setting a figure for a fair price for analytical and consulting work, a check on the comparison of costs so as to quote on large amounts of tests (*viz.*, more than one at a time), keep a close watch on the speed and efficiency of the various workers, determine the value of unfinished work, have a complete record at all times of the costs of promotion of prospectives, a perpetual record of the costs on contracts, and the value of the various kinds of income and their cost.

The difference in keeping these costs in a laboratory is apparent within two to three months after the installation. The operation of these records does not require any large force to keep it running and the time in preparing the cards by the employes does not in any way interfere with their regular work.

FRED W. FEUERBACHER

QUOTATIONS

PROTECTING SCIENTIFIC RESEARCH AT THE POLLS

AT the polls in November, in California, Colorado and Washington, scientific medicine will be tried at the bar of public opinion. The verdict will depend in part on public knowledge of the attainments and conduct of physicians in the past. The true physician, as attorney for the defense, will be actively campaigning against the antis of all kinds, and he will be especially active on election day, when the case goes to the jury.

In Colorado and in California, the people will decide by popular vote whether medical research involving the use of living animals shall be prevented. The antivivisectionists in these states, mistrusting or despising their legislatures, are seeking, through the initiative, to bring about the enactment of such measures by playing on the ignorance and the emotions of the people. No properly informed person can vote in favor of the antivivisectionist measures proposed.

In Washington, the contest is being fought

under the referendum to restrict the activities of the health authorities with respect to the sanitary and hygienic control of the public schools. The foes of scientific medicine, among them those who even deny the existence of disease, procured the passage of an act in 1921 granting to parents the privilege of forbidding examination of their children in school by the health authorities. The public health forces of the state, recognizing the danger to public health inherent in this measure, have procured its submission to the people, and it will be voted on, November 7. The demand for this uncivilized legislation was presumably due to recognition, by the enemies of medical science, that medical mysticism and quackery can not thrive in a community enlightened with respect to modern medicine, and that the public schools constitute the great channel through which the people can be enlightened and future generations gain from the past. In fact, opposition to the rejection of this measure is an attempt to destroy one of the most effective methods of teaching facts concerning disease, namely, by their active application in school administration.

In California, members of two of the cults that now infest the medical underworld are fighting through the initiative to free themselves from control. The liberal and fair-minded provisions for licensing their practitioners do not satisfy them. Chiropractors have been defying the law, and, when convicted and sentenced, have gone to jail rather than pay fines, thus posing as martyrs. Apparently neither cult will be satisfied by any measure that does not allow it to pursue its own course at its own sweet will.

The medical profession must see that no ground is lost to the enemies of scientific medicine and particularly of preventive medicine. The debt of the physician to his patient and his community can not be discharged by proxy. Personal service, intelligently, energetically and loyally rendered, is absolutely essential to success, if the results of the contest are to be certain and complete. Every physician in each of the communities now laboring under the threat of this dangerous legislation should devote an hour or two each day between now and election to enlightening his patients and friends, to informing them as to what is right and to urging them to act on behalf of the right. Thus he will not only be doing his proper part as a true physician but also as a good citizen.—*Journal of the American Medical Association.*

SCIENTIFIC BOOKS

Applied Colloid Chemistry: General Theory. By WILDER D. BANCROFT, professor of physical chemistry at Cornell University. First edition (1921), International Chemical Series. H. P. Talbot, consulting editor. McGraw-Hill Book Company, Inc., New York.

In this volume Professor Bancroft professes to deal with the general theory of colloidal solutions in a new way; he says, "I have written this book deductively." By this one is led to understand that the author sets out to deal with general principles which later may be applied to the particular case involved in the study of colloidal solutions. One should not, then, object that colloidal solution is hardly mentioned in the first third of the book.

In carrying out his plan, the author devotes the first three chapters—or considerably more than one third of the book—to the treatment of the phenomena of absorption in all its phases. This subject is dealt with in the encyclopedic manner so frequently found in German texts, but the style is illuminated and made interesting by that piquancy of suggestion and comment which makes Professor Bancroft's lectures and papers especially attractive. Undoubtedly there is here a valuable summary of the present state of our knowledge of absorption; if any criticism is to be offered, it is that some of the matters dealt with, while important from the point of view of general absorption phenomena, seem to have very little application to the study of colloidal solutions: as, for example, the outlines of various commercial chemical operations at the end of the first chapter.

The fourth chapter is devoted to surface tension and the Brownian movement. After

the minute attention devoted to absorption it is a disappointment that such a meagre treatment is given of the general relations involved under the head of surface tension. This treatment is confined practically to dealing with the application of the Willard Gibbs surface concentration law to colloidal particles. One wonders why the Brownian movement phenomenon is attached to this chapter as there is given merely a sketchy account which would fit in better under the chapter dealing with "properties of colloidal solutions."

The remaining chapter (V) of the general theory is on "coalescence." This chapter appeals to one as ideal in its scope in that it fulfils the aim laid down by the author in his preface. General phenomena are adequately treated and the application to colloidal work is admirably clinched at its close.

Thus slightly more than one half of the book is devoted to a more or less general treatment of absorption, surface tension, Brownian movement and coalescence. The remainder deals with the preparation and peculiar properties of the following classes of colloidal solutions: (1) suspensoids (Ch. VI and VII); (2) emulsoids (Ch. VIII and IX); (3) non-aqueous colloidal solutions (Ch. X); (4) fog and smoke (Ch. XI); and (5) solid colloidal solutions (Ch. XII). The last chapter (XIII) contains a card catalog account of the thickness of films.

The chapter on the properties of colloidal solutions seems to be quite inadequate for a volume which professes to be a complete treatment of the general theory. While many interesting facts regarding these solutions are given, there is a lack of logical method and perspective in their arrangement. For example, a rather long and intrinsically interesting section is devoted to color phenomena; but the colloidal chemist will hardly admit that this particular property is as important as the electrical properties of these solutions or as the phenomenon of coagulation by electrolytes, each of which is given rather less space.

Perusal of the chapter on gelatinous precipitates and jellies justifies the author's statement in the preface that there is not much known about these materials. What is known is given in a very readable shape. More might have been given regarding the evidences of the existence of a structure in protein solutions as outlined by Professor Brailsford Robertson. It is interesting to have the criticism of a physical chemist on the recent work of Loeb, as given in this chapter.

The remainder of the book consists in general of an encyclopedic account of experimental facts regarding emulsions, foams, fog and smoke: regarding this phase of colloidal work there is known very little more than a series of interesting, but more or less detached, experiments, coupled with some very important commercial applications such as ore flotation and the Cottrell process. It is sometimes annoying to find the practical application of experimental facts so far in advance of our theoretical knowledge of their causes.

The book can be recommended as a mine of information on most of the subjects dealt with. However, from the point of view of an attempt to give a final treatment of the general theory of colloidal solutions it is rather disappointing. Such a general treatise demands not only the excellent treatment here given of absorption phenomena but just as ample treatment of such questions as (1) the relation of surface tension phenomena to small divisions of matter, (2) the Brownian movement of small particles, (3) the electrical charges of small suspended particles, electro-endosmose phenomena, and coagulation of electrolytes, and, say, (4) the physical properties of jellies. One would be justified in expecting in addition an attempt to account for the limiting size attained by these particles in suspension in any given case. In fact one can hardly say "the general theory of the subject once cleared up" with the conviction that such a desirable state of affairs is yet accomplished.

As is true with all the volumes of this series (International Chemical Series), the workmanship is excellent, the references very ample, and the appearance of the whole very attractive indeed. This particular volume will be read with interest and pleasure.

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UNIVERSITY OF TORONTO,
CANADA,
OCTOBER 14, 1922

SPECIAL ARTICLES

THE ORDER OF SCIENTIFIC MERIT

IN selecting groups of one thousand American men of science for statistical study in 1903 and 1909, the workers in each of twelve sciences were arranged in the order of merit for their work by ten of their leading colleagues.[1] The average positions gave the order, and, as there were ten observations of the position of each individual, its probable error could be calculated.

As the writer of this paper is a psychologist and the ultimate object of the work is the study of behavior with a view to advancing scientific research, the psychologists may be used for illustrations of method. William James was placed first in 1903 by the independent judgment of each of the ten observers. The psychologist who stood second had an average position of 3.7 with a probable error of 0.5; the chances are even that his position was between 3.2 and 4.2. The psychologists who stood third, fourth and fifth were assigned, respectively, positions of 4.0, 4.4 and 7.5, with probable errors of 0.5, 0.6 and 1.0. It follows that the relative order of Nos. II, III and IV is not determined definitely, whereas the chances are some 10,000 to 1 that each of these stood below No. I and above No. V. The probable errors increase in size as the work of the men becomes less significant; it is on the average 0.65 places for the first ten of the fifty psychologists and 10.7 places for the last ten. Consequently No. XL on the list would have about one chance in four of falling out of the group of fifty, if the number participating in the arrangement had been very large.

The figures determine not only the validity of the positions, but also the differences in scientific merit among the psychologists, these varying inversely as the probable errors. As men who are about 6 ft. 2 in. tall are likely to differ from each other about ten times as much as men who are about 5 ft. 8 in. tall, so the more distinguished scientific men at the top of the list differ from each other about ten times as much as those toward the bottom, and a unit can be adopted for measuring the differences. This method for converting relative positions into degrees of quantitative differences, which was first used by the writer[2] to measure subjective differences in the intensity of lights has proved to be of wide application.

For a third selection of our thousand leading men of science it seemed desirable, in order to avoid the inbreeding that might occur through selection by a limited group, to obtain a general vote from those competent, and, as before, the new methodological problems have proved to be of interest. The validity of votes appears not to have been considered, yet the problem is wide-reaching and is closely related to the drawing of balls from an urn, which has largely occupied students of the theory of probabilities.

If, for example, the council of the American Psychological Association, which consists of eight members, decides without consultation in favor of a given measure by a vote of 6 to 2, how likely is this to represent the majority opinion of the 432 members? We do not know the distribution of this "population," but if from an urn containing 216 white and 216 black balls, 8 are drawn, the chances are about one in nine that 6 will be white and about one in seven that 6 or more will be white. These may be regarded as approximately the chances that when the membership is about evenly divided a vote of that character will be obtained from the council; and on this basis the desirability of a plebiscite vote may be decided.

In 1916 Mr. Wilson was elected president by the vote in California, which was in his favor by 466,300 to 462,394, giving him a majority of 3,906. It might be supposed that this small majority would readily have been reversed by an indefinitely large electorate, but if the population were equally divided this would probably occur only once if an election were held every day for a hundred years.

If the members of a jury reached their deci-

[1] SCIENCE, November 23, November 30 and December 6, 1906, "American Men of Science," The Science Press, 1910.

[2] *Philosophische Studien*, 1902. See also "Studies by the Method of Relative Position," H. L. Hollingworth, in "The Psychological Researches of James McKeen Cattell," a review by some of his pupils, on the occasion of the twenty-fifth anniversary of his professorship. New York, 1914.

sion without consultation and stood eleven to one for conviction, many would conclude that the chances are eleven to one that the defendant is guilty. As a matter of fact if the total population is divided in the same ratio and the legal fiction is followed that a man is proved guilty or innocent only by unanimous vote of twelve peers, the chance of obtaining a jury which without consultation will be unanimous for conviction are about one in three, of obtaining a jury unanimous for acquittal, only one in many billions. The practise of the courts must ultimately adjust itself to such conditions, and learn whether the unanimous vote of three or five jurymen without consultation is more or less valid than the unanimous vote of twelve after consultation. It must be decided on what probabilities a man shall be convicted and to what extent the chances of innocence shall be considered in imposing sentence.

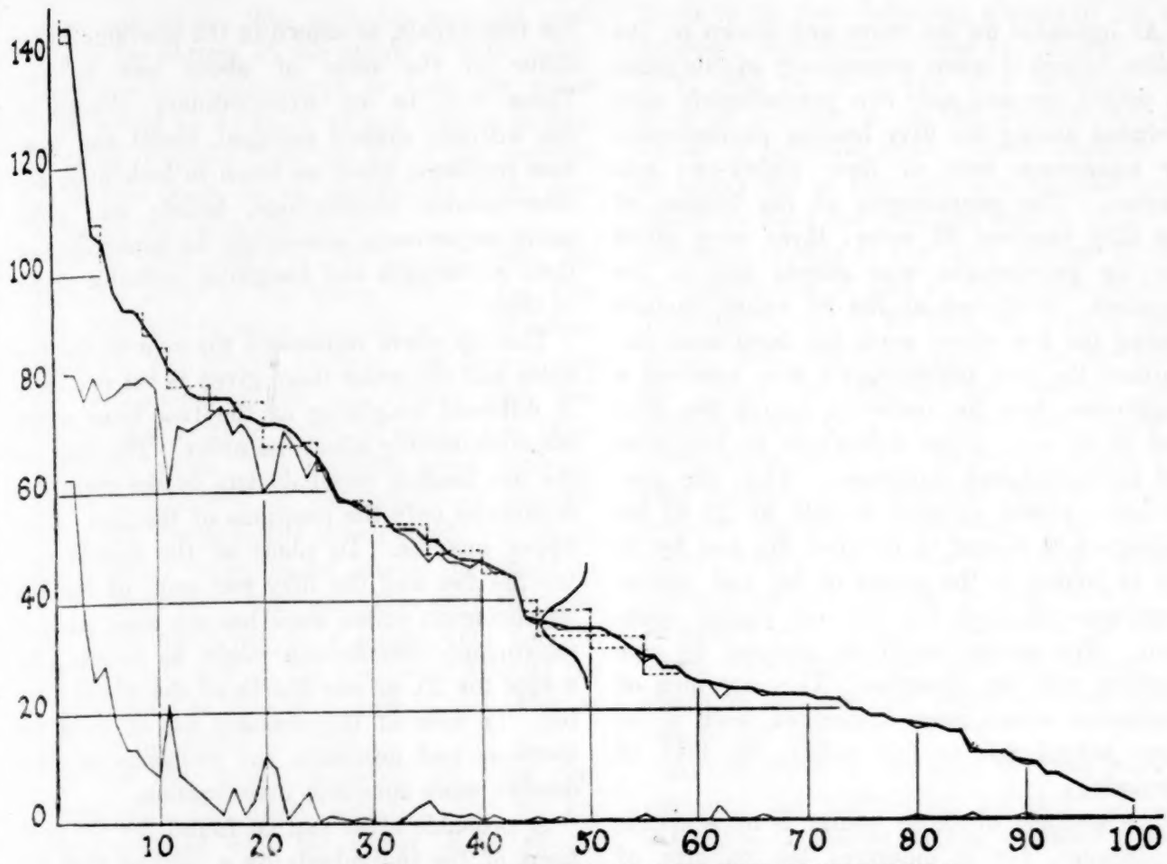
When our rulers are selected and their legislation is determined by votes, it seems strange that knowledge concerning the variable and constant errors is so completely lacking. A decision of the supreme court, which may involve the welfare of hundreds of thousands of children or taxation amounting to billions of dollars, is equally binding whether the vote is unanimous or by a majority of one. It would apparently be as reasonable to require a three fourths vote of the supreme court to invalidate a law passed by both houses of the congress and signed by the president, as to require a unanimous vote of a jury to award petty damages.

The method of voting used to select scientific men might have useful applications in industry. For example, if a bank employs 100 clerks, some of whom will be promoted from time to time, all of them might be asked to check the fifty per cent. and the five per cent. most deserving of promotion. From the records an order of merit for promotion would be obtained, together with the relative value of the men to the bank and the salaries deserved. The data would also throw light on those voting, for the value of the judgment of each is measured by its departure from the average; if any were prejudiced or unfair in their treatment of friends or rivals this would be discovered. The combined judgment of associates is probably a more valid method of selection than the choice of a superior and would presumably lead to better service.

In like manner a group of factory workers or of laboring men might select a boss or leader by vote. If the employer would agree to take one of the five men receiving the most votes, the employees would understand and probably approve the method. Not only would a good selection free from favoritism be made, but the men would share in the control of their work and would be more loyal and more efficient.

The writer has proposed a compromise between the competitive and the semi-communistic systems for payment of the salaries of university professors, according to which, say, five super-professorships with relatively large salaries and large freedom should be established. The difficulty under our present method is that the appointments would be by favor of the administration. If, however, a vote of the teachers in the university, and perhaps of the students, were taken on the basis of desert for research, teaching and service, a method of selection would be used probably more accurate than the choice of the president and at the same time more conducive to cooperation and goodwill.

In the selection by votes of one thousand scientific men the same number for each of the twelve sciences was retained as in the two previous studies, this being nearly proportional to the total number of workers in each science. In the first edition of "American Men of Science" there were listed about 4,000 scientific men, in the second edition about 5,500, and in the present edition, published some fifteen years after the first, the number is about 9,600. The present writer was in 1888 the only professor of psychology in the world. The number of members of the American Psychological Association, which has a professional qualification, increased from 127 in 1903, when the first selection was made, to 432 in 1920. The average number of doctorates conferred in psychology during the five years prior to 1903 was 12.6; it was 40 in 1920. Competition for inclusion among our fifty leading psycholo-



THE DISTRIBUTION OF VOTES FOR ONE HUNDRED PSYCHOLOGISTS

gists or among our thousand leading men of science is thus much more severe at present than was the case when the selections were first made. There are now about 500 working psychologists and about 10,000 scientific men in the United States; the present selection consists approximately of those who form in each science the upper tenth in merit of their work.

In the case of the psychologists, here used as an example, those in the two earlier groups of fifty (except five no longer occupied with psychology or no longer residents of the United States), numbering 48, were asked to send the names of 10 or a smaller number of others whose work warranted their inclusion in such a group. Then those who received two or more nominations were in like manner asked to propose 10 or fewer names. The 52 who received the most votes were added to the original 48 to form a group of 100. These names were placed in alphabetical order on a list, which was sent to them all, with the request to "check ($\surd$) about 50 (namely, about one half) of the names to indicate those who have done the best work in psychology, placing a double check ($\surd\surd$) before about five of those whose work has been the most important." Eighty-three (besides one who replied too late) of the 100 returned the blank and, as each was asked not to consider himself, there were 82 votes. When more than five double checks were assigned they were weighted inversely as the number. The result of the votes can be conveniently shown by curves such as are here reproduced. The middle curve gives the distribution of the 82 votes for the 100 psychologists, the vertical ordinates representing the number of votes, while the individuals are ranged serially along the horizontal axis. The bottom curve shows the number of double checks for each individual, namely, the opinion that he is one of the five psychologists whose work is the most important. The top curve represents the sum of two votes, and the individuals are arranged in order in accordance with this vote.[3]

[3] Similar results have been obtained in each of the twelve sciences, the number of scientific men

As indicated on the curve and shown on the tables (which it seems unnecessary in this place to print) two and only two psychologists were included among the fifty leading psychologists by unanimous vote of their eighty-two colleagues. The psychologist at the bottom of the fifty received 35 votes; three were given for the psychologist who stands last in the hundred. Sixty-two of the 82 voting include among the five whose work has been most important the two psychologists who received a unanimous vote for inclusion among the fifty and 20 do not. Such differences in judgment are legitimate and significant. Thus the psychologist placed eleventh is held by 22 of his colleagues to belong to the first five and by 21 not to belong to the group of 50, and similar conditions obtained for the one placed twentieth. The names could be guessed by one familiar with the situation. They are men of distinction whose more important work is by some judged not to fall within the field of psychology.

The attitude of those voting is of scientific significance, for it measures the validity of judgments. If we assume the average judgment of the 82 psychologists to be nearly correct, the departure from this average measures the competence of the individuals to form such judgments. There do not appear to be group differences dependent on distinction or age, but individuals, as shown in the previous study, differ in the ratio of about two to one. There will be an extraordinary change in our attitude toward political, social and business problems when we learn to look upon our observations, recollections, beliefs and judgments objectively, measuring the probability of their correctness and assigning probable errors to them.

The top curve represents the sum of the two votes and the order there given is the one used. A different weighting of the two votes would not considerably affect the order. The vote for the five leading psychologists in the main discriminates only the positions of the men in the upper quartile. In place of the double vote for the five and the fifty per cent. of the 100 psychologists whose work has the most merit, a satisfactory distribution might be obtained by a vote for 25, or one fourth of the whole number. In view of the constant use of votes for elections and decisions, the problems involved deserve more complete investigation.

A probable error can be found for the positions of the individuals by a method that was apparently first used by the present writer. When eighty of those voting are divided into ten groups of eight each, we have the separate votes of each of these groups and from their variation the probable error of the average vote can be calculated. Thus the psychologist No. L, in the ten groups of eight votes each received, respectively, 4, 4, 2, 1, 4, 7, 4, 3, 2, and 2 votes. The probable error is 0.363, and for the group of eighty votes it is 3.63. The position on the curve assigned by each of the small groups can also be found and a probable error calculated from these ten positions.

The probable errors based on 80 votes (as a rule for each fifth individual) are indicated by the broken vertical line on the curve and when referred to the order of merit by the broken horizontal lines. The probable errors of the votes of the five psychologists last in the fifty are, respectively, 3.4, 2.8, 2.8, 3.1 and 3.6, an average of 3.14. The curve from No. X to No. C is nearly a straight line, the vote decreasing from 79 for No. X to 3 for No. C. Consequently the probable error of the vote when referred to the order is increased by

ranging from 175 chemists to 20 anthropologists. The returns, however, were most complete for psychology, the writer being personally acquainted with nearly all psychologists and a second request having been sent to those who did not reply to the first. There were in all some 130,000 votes to be collected, counted and tabulated. For the treatment of this material I am mainly indebted to my daughter, Miss Psyche Cattell. Dr. Dean R. Brimhall and Dr. Alexander Weinstein have also assisted in the revision of the material and in the computations.

I am under very great obligations to Professor Raymond L. Pearl, of the Johns Hopkins University, and to Professor H. L. Rietz, of the State University of Iowa, for their kindness in reading the manuscript of the paper and for the useful suggestions that they have made. This acknowledgment should not, of course, be construed as involving responsibility on their part.

about one sixth. The probable error of position at the bottom of the group of fifty is 3.6; there are thus only three or four for whom there would be as much as one chance in four of being dropped from the list if the arrangement were made by an indefinitely large electorate of the same character.

In the first study of the psychologists, the probable error at the lower end of the fifty was 10.7, that is, there were 10 or 11 for whom there was one chance in four that they should not be included on the list. There were then ten arrangements in order of merit; now there are eighty votes. The probable error decreases as the square root of the number of observations, and the probable errors in the two cases, other things being equal, should be about as 3 : 1, which is in fact almost exactly the case. The probable error of a single vote for the psychologists low in the group of fifty at the present time is thus the same as by order of merit in the group of 1903.

In the first study, however, we were concerned with the upper quartile, and we are now concerned with the upper decile of the group of American psychologists. If we assume distributions in accordance with the curve of error, the men who now stand at the bottom of the fifty in the present selection will be as able as those who stood about twenty in the first arrangement. An examination of the relative positions of the individuals who are in each of the two arrangements indicates that this tends to be the case. The probable error at the bottom of the fifty selected by votes should be in the neighborhood of those who stood about twenty in the first arrangements. This would make a single vote one half as valid (the ratio of the probable errors in the first arrangement for those near the bottom of the fourth hundred and in the tenth hundred of the thousand being 64 : 125) as a single judgment of order of merit. The figures given should, however, be regarded as indications of method rather than as exact determinations, for they are subject to various errors.

The average position of the survivors of the first group of psychologists in the arrangement of 1903 was (after deaths have been eliminated) 4; it is now for the same individuals 14.8. Those in the four following groups of ten have dropped, respectively, from 11.5 to 18.1; 20 to 27.4; 29.5 to 59.2, and 39.5 to 64.9. This drop in position is on the average less than would be expected if the 10,000 scientific men of to-day are as able and have as good opportunity as the 4,000 scientific men of 1903. The inference is that as the total number increases the proportion of men of distinction decreases. This may be due to the fact that men of special ability find their level apart from the size of the group or because the scientific career attracts less able men or gives them less opportunity than formerly. Both factors are probably present; it is apparent that the situation deserves further investigation. In the previous study it was shown that in the increased competition of a five-year period, those between 40 and 44 years of age remained on the average about stationary; those below 40 gained; those above 44 lost, the loss being in direct proportion to the age.

As the work of the men becomes more important, the differences between the individuals as measured by the probable error of position become greater, the distribution corresponding in a general way to the upper end of the curve of error. In the case of the votes there are complications, for the votes for different men do not have the same weight. The ten who receive the most votes receive nearly all the votes, and in the cases of the few who do not vote for them poor judgment or an error in checking is indicated. Some votes mean that a psychologist stands first or near the top of the list, whereas others mean that he is barely included. Consequently the order and the probable errors in the case of such a vote for one half of the group do not have great validity for the upper part of the distribution. The order is obtained in a satisfactory manner by the double vote, but this introduces further complications in the probable error. In all cases of votes, we have asymmetrical distributions and skew curves. The quantitative relations should be worked out in the first instance for less complicated material than that with which we are here concerned.

In nearly all cases in which probable errors have been applied to psychological data, the

determinations are more exact than common sense would presuppose. Thus the writer found[4] that in grading traits of character by ten individuals on a scale of 100, a position was assigned with probable errors varying from 4.6 for physical health and cheerfulness to 3 for originality and efficiency. All other traits, such as energy, courage, judgment and integrity, were assigned positions with intermediate probable errors, the average being 4, which is nearly the same as the probable error of position as determined by 80 votes of the psychologists near the middle of the 100 in order of merit.

The comparatively small probable errors appear to be due to the fact that there are constant errors which affect the whole group. The psychologists who vote are subject to the same kind of influences, not making in fact independent judgments, but being influenced as a group by the knowledge of what others think and by all sorts of conditions, conventions and restrictions. If a similar vote were taken ten years hence the work of the same psychologists would be viewed from new standpoints and the positions would change to a much greater degree than the probable errors warrant. "Constant" errors are in fact more inconstant and variable than "variable" errors.

In the case of a vote (as in any series of measurements) there are two factors entering into the probable error, one dependent on the quantitative conditions prescribed in advance, the other on the behavior of the individuals. The former may be called the deductive probable error and when the latter is determined by experiment and added to it the whole is the inductive or actual probable error. Thus, if from an indefinitely large number of balls equally distributed between black and white, some are drawn, the most frequent distribution will be an equal number of black and white, but the average departure from equality will increase as the square root of the number drawn and the ratio of departure from equality will decrease as the square root of the number.

If large numbers of white and black balls are distributed in the ratio of 33 white to 47 black, and we draw 80 balls, the most probable number of white balls will be 33. The standard deviation from 33 in a large number of draws will be 4.40, and the quartile deviation or probable error will be 2.97; that is, in one case out of four there will be more than three white balls. The psychologist at the bottom of the fifty received 33 votes out of a possible 80. If an indefinitely large number of psychologists were distributed in this ratio the deductive probable error or error of sampling would be 2.97. The actual probable error, namely, 3.63, is composed of (the square root of the sum of the squares of the two) this deductive probable error and an error or deviation due to the groupings of the psychologists into different "species" with different points of view. The psychologist who stood XII. had a probable error of 3.1. The deductive probable errors are approximately the same for the two individuals, but it is more difficult to form a judgment regarding No. I. than regarding No. XII.[5]

The situation may be illustrated by an instance of general importance. Death rates, birth rates and marriage rates are continually used, but always without probable errors. Thus, for example, the Bureau of the Census issues weekly a bulletin that contains the death rates of the leading cities of the United States, but the figures have no meaning because one does not know whether the different rates are due to chance fluctuations with a limited population or to causes such as a large proportion of infants or an epidemic of influenza.[6] If the

[4] Address of the president of the American Society of Naturalists, SCIENCE, April 10, 1903.

[5] In these cases the actual and the deductive probable errors have probable errors of the order of magnitude of the differences between them, and these differences have only moderate validity. The writer has purposely "not minded his p's and his q's," for it seems that equations are not becoming to one who is not a mathematician.

[6] In the last report received (for the week ending September 2, 1922) the death rate of New Haven is given as 5.8 and of Houston as 13.9. In the same week a year ago the death rate of New Haven was 10 and of Houston 7.6. Without probable errors these figures give no useful information in regard to the conditions in the two cities.

average death rate is 12 per thousand, in a city of 100,000 population there will be about 23 deaths in a week. If black and white balls in indefinitely large numbers are distributed in the ratio of 23 black to 99,977 white and 100,000 are drawn, the most probable number of black balls is 23, but one time in four there will be more than 27. Thus the recorded death rate for a week for a city of 100,000 will normally fluctuate. If it is on the average 12, it will in half the weeks be approximately either as large as 15 or as small as 9.

If the death rate exceeds 15 in two consecutive weeks then the chances are fifteen out of sixteen that it is due to some cause such as an epidemic. The conditions are obviously of practical importance for physicians and health officers. The situation for death rates is nicely illustrated by the illustration that has been used of the distribution of black and white balls in an urn. If the population of the country were 100,000,000 and the death rate were 12 (as it should be, but is not), then 1,200,000 people would die during a year. Among 100,000,000 black and white balls there are 1,200,000 black. But if we draw 100,000 (*i. e.*, take a town of that population) there will be a chance fluctuation as described above. It is also the case that the balls are not completely mixed, there being more black balls in some part of the urn than others. In some places we shall draw a larger proportion of black balls. When there is a negro population or a tenement house population or a large population of very young or very old people, there are relatively more black balls. There are temporarily more black balls in one place when there is an epidemic or the like. In that case we have the analogy of the black balls attracting one another.

This paper has been written to explain the methods used to select the thousand leading American men of science by votes. The psychologists have been taken as an example; if space and time permitted tables and curves might be given for the other sciences and a study of the data might yield results of interest. Such treatment must, however, be postponed or left to others. The object of the present paper will be accomplished if it makes clear that the scientific men have been selected and placed in the order of merit for their work by valid objective methods and that the methods used have wide application. In a subsequent paper the distribution of the scientific men will be considered with special reference to the changes that have occurred in the course of ten years.

J. MCKEEN CATTELL
THE PSYCHOLOGICAL CORPORATION,
AUGUST 1, 1922

THE AMERICAN CHEMICAL SOCIETY

(Continued)

DIVISION OF LEATHER CHEMISTRY
John Arthur Wilson, *chairman*
Arthur W. Thomas, *secretary*

The mechanism of unhairing: JOHN ARTHUR WILSON and GUIDO DAUB. A series of detailed studies was made of the mechanism of the unhairing of skins by means of the sweating process, lime liquors and caustic sulfide liquors. Sections of skin were examined under the microscope at different stages. In liming and in sweating, the first action on the skin itself is the hydrolysis of the epithelial cells of the Malpighian layer of the epidermis, once the cells are destroyed, the remainder of the epidermis, the hair and the sebaceous and sudoriferous glands are completely separated from the derma and can then be removed mechanically. In the sulfide method, the alkali destroys the corneous layer of the epidermis and the skin appears to be freed from epidermal matters on its surface long before the alkali has penetrated to the depth of the hair bulbs. Where this method has been employed, the hair bulbs are usually found intact in the finished leather. The paper is illustrated with photomicrographs.

Pancreatin as an unhairing agent: JOHN ARTHUR WILSON and ALBERT F. GALLUN, JR. When calf skin is swollen in dilute caustic soda, neutralized with sodium bicarbonate, and then put into a suitable solution of pancreatin at 25° C. exposed to air, the hair is completely loosened in 24 hours, but the action is not due to the enzyme, since it is checked by covering the solutions with a layer of toluene. At 40° a solution of pancreatin fails to cause a loosening of the hair of fresh skin because the corneous layer of the epidermis is impermeable to the enzyme and

thus prevents it from attacking the soft Malpighian layer below. When a skin has previously been swollen by acid or alkali, and the corneous layer rendered softer and more permeable, a solution of pancreatin at 40°, even under toluene, will not only destroy the Malpighian layer of the epidermis and loosen the hair, but it will also dissolve the elastin fibers of the skin, thus effecting both unhairing and bating in a single bath.

A study of the strength of proteolytic enzymes in the process of bating: CHARLES S. HOLLANDER. During comparative tests of bating with dung bates and with pure enzymes, tests were made at intervals of the strength of enzyme in the liquors, by the casein method. The concentration varied considerably with time in the case of the dung but remained practically constant when pure enzyme preparations were used.

The hydrolysis of collagen by trypsin: ARTHUR W. THOMAS and FRANK L. SEYMOUR-JONES. It is shown that collagen is readily digested by trypsin under proper conditions, and that it is unnecessary to subject collagen to chemical or pepsin pretreatment in order to render it vulnerable to tryptic action. This refutes the generally accepted belief based on the statement of Kuehne (1887) that trypsin can not hydrolyze collagen.

The points of minimum plumping of calf skin: JOHN ARTHUR WILSON and ALBERT F. GALLUN, JR. A study was made of the change in degree of plumping of calf skin at different acidities and alkalinities. There are two points of minimum plumping, one occurring at a value of 5.1 and the other at 7.6 on the p_H scale. Available data seem to indicate that these two points of minimum represent two different forms of skin protein, one stable only in acid solution and the other in alkaline solution.

Direct determination of plumping power of tan liquors: JOHN ARTHUR WILSON and ALBERT F. GALLUN, JR. The degree of plumping of skin in a given tan liquor is measured by the ratio of its resistance to compression when taken from the tan liquor to its resistance to compression under standard conditions. The method can be conducted with extreme sensitivity and is capable of making the measurement in actual tannery practice.

Effect of hydrogen-ion concentration upon the analysis of vegetable tanning materials: JOHN ARTHUR WILSON and ERWIN J. KERN. The per cent. of tannin found by the A. L. C. A. official method increases with p_H value to a maximum at 8 and then decreases rapidly towards zero. On the other hand, p_H value appears to have no effect upon the determination by the Wilson-Kern method over the range 3.6 to 7.3, but the rate of tanning of hide powder decreases rapidly with increasing p_H value above 7. The rate of filtration of tan liquors is markedly affected by change of p_H value, which may be attributed to changing degrees of dispersion of some of the solid matter. The addition of lime to tan liquors causes a precipitation of tannin, but only at p_H values above 7.2.

Stability of the hide-tannin compound at different p_H values: JOHN ARTHUR WILSON and ERWIN J. KERN. Leather is resistant to washing in neutral or acid solutions, but is broken up into protein and tannin by alkaline solutions. The decomposition begins at $p_H = 7.7$ and proceeds at an increasing rate as the p_H value is raised above this value.

The concentration factor in the fixation of tannins by hide substance: MARGARET W. KELLY. The relationship between degree of fixation of tannin by hide substance and the concentration of the vegetable tanning liquors has been worked out for a number of important extracts. All show a steady increase in tannin fixed, as concentration increases, up to a maximum tannage followed by a sharp drop in more concentrated liquors.

The hydrogen-ion and time factors in the fixation of tannins by hide substance: MARGARET W. KELLY. The combination of vegetable tannins with hide substance is shown to depend upon the hydrogen-ion concentration of the liquor to a most pronounced degree. Over a broad range of hydrogen-ion concentration, an M-shaped tannage curve is obtained. In acid solutions the greatest fixation is obtained at $p_H+ = 2$ to 3, falling off at greater acidities. On the less acid side of $p_H+ = 2$ to 3, the fixation decreases to a minimum at $p_H+ = 5$, the isoelectric point of collagen, then increases to a second maximum at $p_H+ = 8$, and at greater alkalinities falls off approaching zero. The second maximum at $p_H+ = 8$ is much lower than the principal maximum fixation at $p_H+ = 2$ to 3. Explanation for this behavior is submitted in the original paper.

The influence of neutral salts upon the fixation of tannins by hide substance: ARTHUR W. THOMAS and MARGARET W. KELLY. Both sodium chloride and sodium sulfate decrease the fixation of vegetable tannins by hide substance at $p_H+ = 3$; sodium sulfate to a greater extent than sodium chloride. At $p_H+ = 5$, sodium chloride in low concentrations promotes the fixation; at

higher concentrations it inhibits fixation, as sodium sulfate does at all concentrations. At $p_H+ = 8$, both salts decrease the fixation, but not to the same extent. Explanations for the differences in behavior are given based on the Donnan effect on the collagen and the action of the salts in altering the degree of dispersion and diffusibility of the tannin particles.

The difference in kind or degree of tannin fixation as a function of the hydrogen-ion concentration: ARTHUR W. THOMAS and MARGARET W. KELLY. It has been shown that after removing all water soluble substances from freshly prepared leather, treatment with alcohol will extract varying amounts of tannin depending upon the hydrogen-ion concentration at which the leather was tanned. For example, hemlock and gambier leathers tanned at $p_H+ = 3$ will yield about 25 per cent. of their fixed tannins to alcohol extraction, a smaller amount when tanned at $p_H+ = 5$, and practically none when tanned on the alkaline side of $p_H+ = 5$. If the leathers are drastically dried before alcohol extraction, very little alcohol soluble matter is found. These preliminary experiments are to be continued with the view of throwing more light upon the differences in kind or degree of tannage at differing hydrogen-ion concentrations.

The tannin-gelatin reaction: ARTHUR W. THOMAS and ALEXANDER FRIEDEN. The mutual precipitation of tannin and gelatin depends to a very large degree upon the hydrogen-ion concentration of the solution. It has been shown that the gelatin-salt test for tannin is sensitive to one part of tannin in 110,000 to 200,000 parts of water, depending upon the source of the tannin, and provided the hydrogen-ion concentration of the solution is adjusted to its optimum. This optimum varies with different extracts, ranging from $p_H+ = 3.5$ to 4.5. The details are given in the original paper. It is also shown that it is unnecessary to prepare the gelatin-salt test reagent daily. This reagent kept for two months at summer temperature when covered with a layer of toluene and its delicacy was not impaired in that time. How much longer it would keep is unknown.

Are vegetable tannins amphoteric? ARTHUR W. THOMAS and STUART B. FOSTER. Six common vegetable tanning materials were investigated by the electrophoresis method indicating that all are amphoteric, *i. e.*, changing from anodic migrating to cathodic in the p_H+ range of 2.5 to 2.0. Hydrogen-ion concentration precipitation curves are also given for the extracts studied.

The practical color measurement of vegetable tan liquors: R. O. PHILLIPS and L. R. BROWN. It is suggested that color measurements are best made by tanning pieces of skin under standard conditions.

The acidity of synthetic tans: S. KOHN, J. BREEDIS and E. CREDE. The active principles of most synthetic tans are sulfonic acids in the preparation of which an excess of sulfuric acid is used. It is relatively easy to find out whether or not sufficient alkali has been added to neutralize this excess. But sulfuric acid being neither the sole nor the worst of the undesirable ingredients occurring in some syntans, it is important to devise methods by which preparations containing undesirable ingredients can be detected. To the methods suggested previously a new one is added which is based upon comparative observations of the part played by the acidity of syntans in the precipitation of gelatin.

The colloid chemistry of basic chromic solutions: FRANK L. SEYMOUR-JONES. A review of the literature upon the nature of chromic solutions showing their very complex and as yet unsettled condition of solution. Ultrafiltration experiments failed to show the presence of any colloidally dispersed chromium compound in the ordinary single bath chrome liquor. The experiments are preliminary in nature and further investigation is contemplated.

The electrophoresis of chromic solutions: FRANK L. SEYMOUR-JONES. The Thompson-Atkin theory of chrome tanning, which postulates a negatively charged chromium complex as the tanning agent, is criticized and shown not to be of general application, if at all, since chromic solutions which did not show any evidence of negatively charged chromium complexes tanned hide powder. It is true, however, that in certain basic solutions of chromic sulfate, part of the chromium exists in a negatively charged complex, while this does not occur in the basic chloride nor yet chrome alum.

The interpretation of the influence of acid on the osmotic pressure of protein solutions: JACQUES LOEB. When osmotic equilibrium is established between a solution of casein and hydrochloric acid enclosed in a collodion bag and an outside aqueous solution free from protein, the hydrogen-ion concentration is always greater in the outside solution than in the casein solution. The observed osmotic pressure is accounted for quantitatively by the difference in concentration of hydrochloric acid in the two solutions, without taking into consideration any possible osmotic

pressure of the casein itself. The observed potential difference between the two solutions in millivolts always has the numerical value equal to 59 times the difference in p_H value between the two solutions at 24°, proving that the inequality in p_H value is determined by Donnan's equation for membrane equilibria.

A preliminary study of a plunger type of jelly strength tester: S. E. SHEPPARD and S. S. SWEET. In previous papers the authors have described an instrument for measuring in absolute units the rigidity of gelatin jellies. They have used the results to check the performance of plunger types of jelly strength testers. In these instruments a plunger resting on the jelly is loaded to produce a fixed arbitrary depression or distortion. The authors have devised an instrument with a balanced beam, and continuous chainomatic loading. Hence the load : deflection, or stress : strain curves can be plotted for constant rate of loading. The points investigated were: (1) Effect of shape of plunger. It is found that with plungers having a rounded base the area of contact varies with the load, and unreliable load : deflection curves are produced. The most satisfactory plunger is a frustum of a cone, with the larger base resting on the jelly surface. Families of straight lines passing through the origin are obtained in good agreement with Hooke's law. (2) Ratio of diameter of plunger to diameter of vessel. Using plunger heads of above shape, this ratio should be less than a certain value, or spurious rigidity; hence spurious jelly strength will be obtained. This is a function of the absolute jelly strength (rigidity) so that comparisons for grading may be vitiated. (3) Ratio of depression to height of jelly. Similarly the depth of jelly must be large compared with the depression, using the same plunger diameter. These results are discussed in connection with recent work on the structure of jellies.

On the non-isotropic swelling of thin sheets of gelatin: S. E. SHEPPARD and S. S. SWEET. By coating definite amounts of gelatin solution of various concentrations, etc., on suitably prepared glass plates, after drying flat sheets of definite thickness and area can be stripped off. The swelling of these in water and aqueous solution is not isotropic, *i. e.*, not uniform in all directions, but greatest for the thickness. It is found that the *ratio* of volume increase to area increase differs for different gelatins, and also depends upon the treatment, becoming lower, for example, on hardening with formaldehyde.

The preparation of gelatin free from ash and hydrolytic decomposition products: S. E. SHEPPARD, FELIX A. ELLIOTT and MISS A. J. BENEDICT. A 5 per cent. solution of commercial gelatin is electrolyzed in a cell of electrofiltros for three to four weeks, the salts passing through the cell into the electrode chambers. This reduces the ash to ca. 0.10 per cent. This deashed solution is then precipitated with acetone, thus removing hydrolytic decomposition products and further reducing the ash to ca. 0.01 per cent. This gelatin is then redissolved in conductivity water, chilled in sheets and dried. The reaction of a solution of such gelatin in solution is about 4.8 H-ion. This gelatin is useful for all research work on gelatin as well as providing a definite material for culture media which can be brought to any particular reaction with complete knowledge of salts present.

The hygroscopicity of hide glues and the relation of tensile strength of glue to its moisture content: E. BATEMAN and G. G. TOWN.

The two forms of gelatin and their isoelectric points: JOHN ARTHUR WILSON and ERWIN J. KERN. In a tenth-molar phosphate solution of increasing p_H value, gelatin shows two points of minimum swelling, one at 4.7 and the other at 7.7. It is suggested that the two points of minimum represent the isoelectric points of the gel and sol forms of gelatine, respectively.

Some modern problems in leather chemistry: EDMUND STIASNY. The striking feature of modern research in leather chemistry is the entirely different point of view in the choice and treatment of problems as compared with the period previous to ten years ago. The older experimentation was entirely from the standpoint of direct practical investigation, while in pure research for the purpose of deep understanding of the processes, entirely unfettered by any thought of immediate practical utility, in which the entire structure of modern science is employed, activity has become evident only within the past decade. Professor Procter is the connecting link between these two eras and the example set by him in his scientific attitude is especially evident in the United States. A few of the problems of timely interest are the chemical nature of collagen, the mechanism of bating and what is called the astringency of vegetable tannins. (The author reviews the results of his experimentation upon these problems which will be published in full later). The ultimate aim of all research in leather chemistry is the widening and deepening of our fundamental knowledge of this as yet very undeveloped field.

DIVISION OF GAS AND FUEL CHEMISTRY

A. C. Fieldner, *chairman*

R. S. McBRIDE, *secretary*

Chemistry of combustion: W. K. LEWIS. The present state of knowledge of combustion is reviewed, the field being divided into, first, combustion within the fuel bed; second, distillation of the volatile matter in the fuel; and, third, the burning of the combustible gases over the fuel bed. The composition of the gases within the fuel bed is discussed and the effect of increased rate of combustion shown. The velocity of the reaction of C plus O_2 equals CO_2 is shown to be dependent on the speed of diffusion and not on the specific reaction rate. The modern concepts of the combustion of hydrocarbons are also discussed.

Combustion of powdered coal: HENRY KREISINGER and JOHN BLIZARD. This paper considers essential factors in burning powdered coal, and gives a review of some tests carried out by the U. S. Bureau of Mines and the Combustion Engineering Corporation. The size of the particles, their motion relative to the surrounding air and methods of bringing them into contact with fresh supplies of air as they burn are discussed. A furnace and burner designed for burning powdered coal are shown and the principles of the design explained. The principal results of tests carried out on a large boiler are shown graphically.

Simultaneous combustion of CO and hydrogen: R. T. HASLAM. A review of the literature shows that doubt exists whether the combustion of hydrogen and carbon monoxide is of the second or third order. Experimental evidence is offered to show that when carbon monoxide and hydrogen burn simultaneously with oxygen in free space the combustion reactions are both trimolecular and that the ratio of the reaction velocity constants in the equation $\frac{d}{dt}(CO) = K_1(CO)^2(O_2)$ and $\frac{d}{dt}(H_2) = K_2(H_2)^2(O_2)$ is $\frac{k_1}{K_2} = 0.35$.

Some aspects of combustion of gases: HENRY L. READ.

A study of the water gas reactions: R. T. HASLAM, F. L. HITCHCOCK and E. W. RUDOW. The action of steam on carbon through the temperature range of 650 degrees centigrade to 1200 degrees centigrade was studied by means of varying the pressure of the steam and results indicated: First, that below 900 degrees the major reactions are (B) C plus $2H_2O$ equals CO_2 plus $2H_2$; (D) C plus CO_2 equals $2CO$; whereas above 900 degrees the reactions are (A) C plus H_2O equals CO plus H_2; (B) C plus $2H_2O$ equals CO_2 plus $2H_2$; (D) C plus CO_2 equals $2CO$; second, that the undecomposed steam is shown to be the controlling factor in the CO and CO_2 ratio rather than the temperature at which reactions take place; third, equations are given showing the per cent. of CO_2 as a function of the undecomposed water; fourth, considering the rate of reaction (B) as unity it was found that (A) at temperature below 900 degrees centigrade reaction (A) is practically non-existent and that the velocity constant of reaction (B) is 2.0; (B) at temperature above 900 degrees the velocity constant of reaction (A) is 1.0 and that of (D) is 2.18.

Producer gas reactions: W. K. LEWIS. Application of equations in previous article (water gas reactions—Haslam, Hitchcock and Rudow) showing effect of temperature, steam-air ratio and time of contact on composition of producer gas.

The combustion of gaseous fuels: GEORGE F. MOULTON. Gas fuels commonly distributed for domestic and industrial purposes by gas companies vary in heating value from 450 to 1,100 B.T.U. per cubic foot. These gases vary in specific gravity from 0.35 to 0.70, and the pressures at which they are delivered to the consumer's appliance vary from 2 to 12 inches of water. The result of these large variations in heating value, specific gravity and pressure is that the manufacture of efficient gas appliances has been greatly retarded; the knowledge of correct adjustment of appliances is very vague, and modification of existing standards of quality has been made difficult because the effect of these changes on quality of service, efficiency of utilization and safety of operation has been difficult to determine. The range of operation of burners as well as the efficiency that can be secured will depend primarily on the characteristics of the flame. This paper shows how these flame characteristics are modified by a change of injection of primary air which may be caused by variations in gas rate, pressure, composition of gas, etc.

Combustion in engine cylinders: H. C. DICKINSON. The process of combustion in engine cylinders presents some very interesting problems which demand a radical departure from the usual methods of reasoning and experiment. When a combustible mixture of gases burns at constant volume no two successive portions of it are burned at the same pressure or the same temperature or at the same time. The reactions do not take place simultaneously throughout the mass and the law of mass action does not apply, except to

infinitesimal elements of the charge. The times involved are excessively short and it is doubtful if chemical equilibrium is ever attained at any point until the important phases of the process are passed. The importance of the internal combustion engine in the present scheme of things demands much more precise knowledge of the chemistry involved in its operation.

Factors governing the selection and use of fuel for industrial heating operations: J. A. DOYLE. This paper deals with factors governing the selection and use of fuels in the production of chemical products subjected to the action of heat in the process of manufacture. The necessity for considering the physical form and chemical association of a given form of fuel, in addition to the heating value of that fuel and the mechanical characteristics of the appliance for generating, applying and utilizing heat in the product is stressed. The influence of excess air upon the heating value of the different fuels, the composition of the atmosphere surrounding the material to be heated, the changes in composition of the combustible mixtures and the products of combustion of the different fuels with varying amounts of air are shown. The influence of process requirements and plant conditions upon the choice of fuel is outlined. The above points are illustrated by graphic charts showing the relation of the various factors and their influence upon the final result. The paper is in substance a plea for a broader consideration of the problem of fuel utilization from the standpoint of the quality and cost of the finished product, and the necessity for developing a better understanding on the part of those concerned with industrial heating operations of the influence of the conditions governing combustion upon the use of fuel and the utilization of heat.

Methods of utilizing the coke produced by low temperature carbonization of coal: HARRY A. CURTIS. The coke obtained by low temperature carbonization of coal is soft, light and quite unsuited for general use as a smokeless fuel. Attempts have been made to increase the density of the coke by compressing the coking coal mass in the retort, but these methods have not attained commercial success. By pulverizing the soft coke it can be burned efficiently in powdered fuel equipment, but preliminary tests of the fuel on a Coxe stoker gave unsatisfactory results. By grinding the coke, briquetting it and carbonizing the briquets a very high grade smokeless fuel is obtained, but the cost of these operations is high.

The forms of sulfur in coke—a physico-chemical study of the sulfur held by carbon at high temperatures: ALFRED R. POWELL. A phase rule study of the system, carbon-sulfur, at high temperatures showed that the sulfur exists in two distinctive forms: (1) a very stable form which exhibits all the properties of a solid solution, and (2) free sulfur physically absorbed by the carbon. Coke may contain both of these forms in addition to some sulfur combined with iron as ferrous sulfide. At temperatures in the neighborhood of 500° C. the ferrous sulfide of coke oxidizes very readily in the presence of air to ferric oxide and free sulfur. This reaction seems to occur during the quenching of coke and explains the disappearance of ferrous sulfide from coke rather than any reaction which occurs during the coking process.

A specific apparatus for gases: T. R. WEYMOUTH, R. P. ANDERSON and J. R. FAY. This new device consists of a thin orifice and a small capillary tube in series and makes use of the fact that the differential pressure resulting from the steam-line flow of gas through a capillary tube is independent of the specific gravity of the gas while the differential pressure resulting from the flow of gas through a thin orifice varies directly with the specific gravity of the gas. The flow of gas through the orifice is kept constant by holding a certain differential pressure on the capillary tube and the differential pressure on the orifice is calibrated to read specific gravity of the gas.

The examination of low-temperature coal tars: JEROME J. MORGAN and ROLAND P. SOULE. A critical review of the adaptability and limitations of procedures available for examination of low-temperature tars. The lower boiling phenols are determined by Raschig's nitration method together with methods based upon freezing point and densities of binary and ternary mixtures. Paraffins and naphthenes are freed from unsaturates and aromatics by 98 per cent. sulfuric acid. The proportions of paraffins and naphthenes in their mixture are found from density-boiling point curves. For qualitative examination non-saturated hydrocarbons are separated by liquid sulfur dioxide. No method is known for estimation of unsaturates in presence of aromatics.

The Becker combination coke oven: HAROLD J. ROSE. The latest advance in by-product coke oven design is represented by the Becker combination oven, a modification of the Koppers oven. Greater heating efficiency, better coke quality and

increased strength of construction are obtained by a novel design which provides for the heating and regeneration of the coke and pusher ends of each oven as separate units. In this construction, gases of combustion pass over the top of each oven and down through the opposite flues of the same end, instead of passing longitudinally to the end of the same line of flues. Details of design will be fully illustrated by means of lantern slides.

Methods for studying the macrostructure of coke: HAROLD J. ROSE. The study of the structure of coke has been greatly neglected, due largely to the difficulties involved in preparing specimens, and in satisfactorily reproducing the structure photographically. This paper opens the way to the comprehensive study of coke macrostructure, by the use of novel methods. After sectioning the coke, the author impregnates the cut surface with a white hydraulically hardening compound, after which it may be polished to any desired degree. The excellent contrast of black coke with white impregnating compound makes detailed study and reproduction an easy method. Another novel method is the direct reproduction of the coke surface as obtained by inking the polished coke surface and printing with it on enameled paper. The article is copiously illustrated with macrophotographs.

A new electric furnace for the determination of the by-product yields of coal: HAROLD J. ROSE. The by-product yields obtainable from coal when coked in a by-product coke oven may be determined by laboratory distillation tests. Since the yield of by-products is seriously affected by small variations in distillation conditions, the laboratory determination requires the most rigidly controlled testing conditions. For this purpose a furnace, consisting of a deep trough formed from a number of U-shaped electrical heating units with individual control, has been developed, and is in regular use for research and testing purposes. Typical results are given to show the agreement of duplicate determinations made with this apparatus. The furnace is described and fully illustrated.

The combustion of coal which has been a long time in storage: S. W. PARR and T. E. LAYNG. It has been fairly well demonstrated that coal in storage does not lose any appreciable number of heat units. Previous investigations show the seeming loss in B.T.U. to be due to a corresponding increase of weight resulting from absorbed oxygen. However, when coal, especially fine material which has been long in storage, is burned, the result is very likely to show a low efficiency and indeed such coal sometimes seems to be unwilling to burn at all. The results noted in this paper account for the behavior of such coal to be due to the fact that coal in the finer sizes, especially coal of the mid-continental type, has a very large absorptive capacity for oxygen, that, because of the colloidal character of the coal substance such absorbed or adsorbed oxygen is held so tenaciously that when discharged by heat it has reached the combining stage and goes off as CO_2. The blanketing effect of this gas over the fuel bed results in a deadening of the fire and a loss of efficiency.

A study of solvents for the separation of coal into its type constituents: R. S. FISHER with S. W. PARR. The greatest advance in coal studies during recent years has resulted from the use of solvents which separate the coal into its type constituents without decomposition of their chemical structure. British and continental investigators have made much use of pyridine, which, however, seems to lack this prime requirement of a true solvent in that it enters into chemical reaction with certain of the coal constituents. The work here described gives data in the use of benzene, toluene and xylene, with methods for the use of the latter solvent which excels all others in the amount and completeness of removal of the soluble material. This is a preliminary report only as the work is being actively followed up because of the promise of larger yields more easily recovered than by methods in vogue heretofore.

The softening point of coal—its determination and significance: T. E. LAYNG, W. S. HAWTHORNE and A. W. COFFMAN, with S. W. PARR. References to the softening point of coal are frequent in fuel literature. The term heretofore has had a very vague meaning. This paper describes a method for its determination at once simple and accurate. The interesting fact has been developed that under uniform conditions the softening point repeats itself with marked constancy. Moreover, it is evidently a characteristic factor for varying types of coal as also for coal which has been for different lengths of time in storage. That is to say, it is a value which runs parallel with the oxygen content. No less striking is the solidifying temperatures, which result in a curve symmetrical with the range exhibited for the softening-temperatures. Description of the apparatus with results on numerous coals are given. The results are exceedingly interesting and may answer such questions as: What is the type of coal? What would be its behavior in storage? What kind of coke would it make and what modi-

fication of existing methods would improve its coking qualities? The report is preliminary only and further experiments are in progress.

The fractional decomposition of coal and coal components: S. W. PARR and T. E. LAYNG. Next to the fractionation of coal by solvents the fractional decomposition of coal in its combined form and also of its separate type constituents has furnished the most valuable data concerning the character of different types of coal and their behavior in the process of decomposition. Investigators in this field heretofore have failed to appreciate the significance of oxygen either combined or absorbed, but especially the rôle of the oxygen held in some form of absorption. The results as interpreted from the standpoint of this investigation have an entirely new meaning and are of fundamental importance in connection with studies along the line of coal carbonization.

A proposed theory of coal carbonization: S. W. PARR and T. E. LAYNG. This paper presents the summarized results of the several contributory lines of investigation on topics directly related to the carbonization of coal. The evidence seems to be conclusive that a correct theory for coal carbonization has yet to be written. It is not to be inferred that its final formulation is attempted in this paper. However, the results now in hand point out the general outline. The basic principle seems to be that the bonding effect which results in the production of a coherent mass is due not only to the presence of bituminic material, but to the absence or control of deleterious products of decomposition from the cellulosic substance, which under certain conditions may weaken or completely nullify the bonding property of the bituminic bodies. The production of coke is therefore not a simple matter of destructive decomposition of organic matter, but a destructive decomposition accompanied by cross reactions which may, under varying circumstances, produce an altogether different result as to the physical character of the final product. The paper is a preliminary report only.

Utilization of gas at low pressures: ANNA P. WARREN. So much has been said about the use of gas and so little information of practical value to the domestic consumer is available that experiments under actual home conditions are in progress to determine the conditions necessary for maximum thermal as well as practical efficiency at the minimum pressure and rate of consumption of gases varying in heating value from 1,150 B.T.U. to 500 B.T.U. per cubic foot. Up to the present time, under standard conditions, natural gas is the only commercial gaseous fuel that will give relative high thermal as well as practical efficiency under one ounce pressure.

Available hydrogen in coal and a direct method for its estimation: JOSEPH D. DAVIS. Available hydrogen, called "disponsible" hydrogen by German writers, is hydrogen contained in coal in excess of that required to satisfy the total oxygen calculated to water. It is customary to calculate the available hydrogen of a coal from its ultimate analysis. The method described in the paper is volumetric. It is similar to that used for the analysis of combustible gases wherein the slow combustion pipette is used. The coal is burned in a known volume of oxygen and the volume contraction observed after the combustion has taken place is due to oxygen consumed in burning the available hydrogen to water.

Thermal operation of modern regenerator coke ovens: D. W. WILSON, H. O. FORREST and C. H. HERTY, JR. Briefly stated, there have been included in this report: first, discussion of data needed to show completely the thermal operation of a modern regenerator coke oven battery; second, description of the experimental methods employed to obtain the needed data together with a table giving experimental figures obtained; third, a table balancing total heat input against total heat output is given, with a discussion of this and a calculation of the efficiency of the ovens; fourth, a so-called sensible heat balance is tabulated, the net heat effect of the coking process is discussed and the relation between the sensible heat balance and the exothermicity of the conversion from coal to coke is indicated.

Producer gas from powdered coal: R. T. HASLAM and L. HARRIS. Aside from the possibility of using a low grade fuel, the use of powdered coal for the manufacture of producer gas would give a constant composition gas free from tar, thus being easily cleaned, and the producer would be flexible, rapidly handling changes in load up to full capacity. As a result of experimental work not yet completed a gas of 12.0 per cent. CO and 7.0 per cent. CO_2 has been generated. Theoretical and experimental considerations show that the main factors are, first, high temperature in the combustion chamber (1,100-1,300° C.); second, air for combustion highly pre-heated (900-1,000° C.); third, coal finely pulverized, and fourth, air and coal well mixed together and so maintained until the end of the reaction.

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Secretary